A MANUAL

OF

PHYSICAL DIAGNOSIS

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SEVENTH EDITION, REVISED BY

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PREFACE TO THE SEVENTH EDITION.

Recent advancements in the laboratory side of diagnosis have discouraged the acquisition of that thoroughness and skill in the employment of simpler methods which were so essential to the earlier masters of clinical medicine. Even among instructors the disposition to subject every difficulty in diagnosis to the *x*-ray, polygraph, electrocardiograph, etc., before the older means of examination have been exhausted, is daily developing. This tendency to adopt the dramatic, and slight the direct use of his unaided senses, doubly appeals to the student, for he naturally fails to foresee how often in practice he will lack the advantages of such apparatus.

The particular need which this manual was intended to fill, and which it is expected that it will again fill, is the demand of the student and of many graduates in medicine, for simplicity, directness, exactness, and skill in dealing with physical signs in health and diseases.

In preparing the present edition it has been the purpose of the Editor to retain, and as far as possible to augment, by his additions and modifications, those features which have heretofore so strongly appealed to the student and the general reader. To this end a

chapter on the Physics related to the subject has been introduced. It is hoped that it will assist the student to correlate the phenomena of auscultation and percussion with the principles he learned during his academic courses. Certain minor methods of examination, as Inspection, Palpation, etc., have been brought into greater prominence than the distinguished Author originally accorded them.

Our knowledge in no phase of internal medicine has progressed more rapidly during recent years than in Cardiac Disorders. Hence, special effort has been exerted to bring the chapters devoted to examination of the Heart into accord with modern ideas. The subject of Arrhythmia has been rewritten and its usual types diagrammatically presented. On page 297 a diagram has been introduced which should enable and encourage the student to visualize the auscultatory signs of cardiac disease.

Finally, the Editor would allude to the satisfaction he has felt in associating his name with a work that bears the vital impress of Professor Flint's genius.

HENRY C. THACHER.

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CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

PHYSICAL DIAGNOSIS.

CHAPTER I.

THE PHYSICAL BASIS OF AUSCULTATION AND PERCUSSION OF THE LUNGS.

Physics of sound—Simple sounds or tones—Intensity—Pitch—Noises—Quality or timbre—Action of resonators—Transmission of sounds—Percussion of bones—Soft tissues—Tissues containing large collections of air—Open and closed cavities—Tissues containing air in minute subdivisions—Auscultation—Transmission of sounds from bronchi through solid lung—Through alveolar tissue—Breath sounds over normal lung—Solid tumors—Pulmonary cavities and pneumothorax—Pleural effusions—Adventitious sounds—Moist rales—Modification due to condition of parenchyma—Consonating rales—Dry rales—Crepitant rales—Pleural friction and pleural splashing sounds.

PHYSICAL BASIS OF PERCUSSION AND AUSCULTATION.

THE more important methods of physical examination of the lungs depend upon *alterations of the sounds* elicited by striking upon the chest wall (percussion) and upon alterations of the sounds normally heard at the chest wall when the patient breathes, speaks or

2

whispers (auscultation). It may be worth our while, therefore, to sketch briefly the characteristics of sounds in general, and also to give particular attention in the main principles governing and modifying sounds under similar conditions than those met with in the thorax.

PHYSICS OF SOUND.

Sound is a *sensation* produced when vibrations reach and stimulate the ear. The human organ of hearing is sensitive to *vibrations* occurring at a rate of between 16 and 40,000 per second, provided they be transmitted to it with reasonable intensity. Whenever we set up vibration in a tuning-fork, drum, string, vocal cord, or what you will, these are *propagated* by the surrounding air in the form of rapidly alternating waves of condensation and rarefaction, which radiate away with great velocity—in air at a rate of 11,000 to 12,000 feet per second. Should the sounding body be in contact with a solid elastic substance, the sound waves may be transmitted even better by the solid than by the air, as along the railroad tracks or iron water-pipes. The ability of solids to transmit sound waves varies with the mass and elasticity—the latter meaning their ability to resume their original form, when that force which altered that form ceases to act. Sound waves may also pass with varying loss of intensity from air to solid, and solid to air again—for example, through the walls from one closed room to another. The *quality of the*

transmitting substance and the distance are as important in determining the sounds we hear as the intensity of the original vibrations.

As the pendulum is the simplest form of a slowly oscillating body, so an elastic rod fixed at one end and free at the other gives us the least complicated rapid vibrator. When two such rods of equal proportions are fixed side by side on a common base, as by clamping in a hand vise, their oscillations strengthen one another, so that they continue much longer in motion, and are therefore best suited for the production and analysis of simple sounds of a fixed uniform wave length. Such a pair of parallel rods constitutes a tuning-fork. The sound produced by them, when their regular rapid oscillation is transmitting its uniform series of waves to the ear, is called a tone. *Tones are sounds of definite uniform wave length.*

Intensity of Sound.—When we examine such a tuning-fork we find that, like a pendulum of given length, its oscillations may vary greatly in size, depending upon the force with which it is set in motion, but the number per minute is an inherent fixed characteristic of the individual instrument; and with one or one hundred tuning-forks of the same elasticity, mass and proportions, tones can be produced which may differ in quantity, but in that alone. *Such differences in quantity or intensity depend merely upon the violence with which the sound waves reach the ear,* and may be brought about on the one hand by altering the force with which the tuning-fork is set in motion; and on

the other hand by varying the distance of the ear from the instrument, or the character of the transmitting medium. The intensity of a sound is simply the loudness with which it is heard.

Pitch.—With tuning-forks of different sizes the tones produced, even though they be equally loud or intense, are not alike, but differ in another attribute called pitch. We find that the smaller the forks, *the more rapid the vibrations and the higher the pitch,* no matter whether the intensity of the tones be great or small. Pitch depends upon the rate with which vibrations of definite periodicity or rhythm reach the ear, and is a characteristic of every such rhythmical sound or tone.

Noises.—When several or many tones of unrelated wave length are simultaneously produced, the resulting sound waves are irregular vibrations without periodicity or rhythm. Such *non-musical sounds have no definite pitch* and are called noises. Although noises have, strictly speaking, no true pitch, in physical diagnosis we are constantly comparing them in regard to this quality. In so doing we are really referring to the pitch of the predominating or of the lowest tone present in these compound sounds.

Quality or Timbre.—Sound waves of equal rate and intensity can be produced from a great number of vibrating bodies and yet even then they are not entirely alike. This is due to differences in what is called quality (or timbre) which are so great that the same notes produced on different instruments are

readily distinguished by even the most untrained ear. These striking, though indefinable, differences in quality (or timbre) depend upon the fact that our sonorous bodies do not confine themselves to the production of their single fundamental tone, but

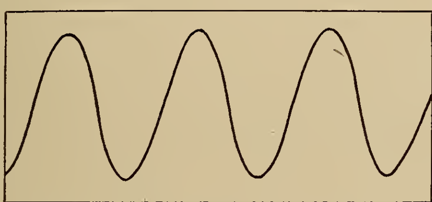


Fig. 1.—Vibration waves of a simple tone (tuning-fork).

Fig. 2.—Vibration waves of intense fundamental tone with faint overtones (violin).

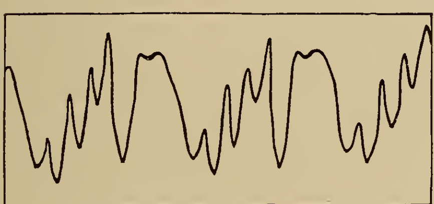


Fig. 3.—A complete musical instrument.

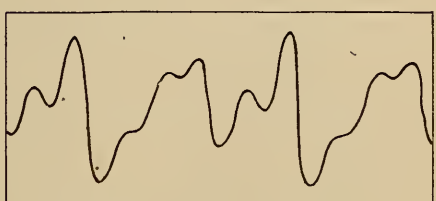


Fig. 4.—Human voice.

Vibration waves in which the overtones are intensified, giving a very distinct individuality to the sound.

Figs. 1–4.—Diagram of musical sound waves composed of a simple tone and of fundamental plus overtones.

add to this secondary regular tones, two, three, four, etc., times the rate of the fundamental. The violin string thus vibrates not merely as a whole but also in parts of one-half, one-third, one-fourth, etc., and the sound produced consists of not only the fundamental but also the *superimposed overtones*. It

is the latter that give quality to sounds; and it is on their faculty of producing overtones that musical instruments depend for their individuality.

Resonators.—Overtones and fundamental tones are magnified by the presence of a sonorous body or resonator whose wall or air-content takes up and *vibrates in unison with the original tones, adding greatly to their intensity and quality.* The resonator, according to its ability to intensify these overtones, is indeed far more important in contributing quality than is the vibrator itself. This is perhaps best emphasized in the case of violin bodies which vary so extraordinarily in value, although their strings are so insignificant in cost. Overtones accompany the fundamental tone of most musical sounds.

In the construction of sounding boxes or resonators for musical instruments the maker's skill is directed to producing a sounding body that will covibrate with sounds of many degrees of pitch. *All elastic structure, however, have their own vibration times,* and when oscillations are transmitted to them at that rate they are set in motion. This is daily seen in the laboratory when, as an ill-balanced centrifuge is gradually increased in speed, now one, and now another pipette rack, beaker or burette begins to rattle, and subsides only when the centrifuge's vibrations have altered to become more or less rapid. It is this which makes it necessary that marching troops break step while crossing bridges, and upon this same fundamental law depends the fact that, if the sound waves

of one tuning-fork reach a fork, string or ball or other sonorous body of similar pitch, the latter is set in action. This law is made of practical use in *analyzing sounds* composed of several tones by exposing a series of resonators to the compound vibration, and noting which resonators are set in covibration. It is also of great importance in the construction of stethoscope bells. When dealing with faint murmurs of low pitch, the old Gannet type of stethoscope not infrequently settled an argument; because the large resonating cavity of its bell intensified murmurs of that pitch. On the other hand, soft murmurs of aortic insufficiency are notorious for occasionally being far better heard by the direct ear than with the popular small-bell stethoscopes. While the complex resonators of musical instruments strengthen sounds of many degrees of pitch, *the simpler resonating body strengthens a limited set of sound vibrations.*

The Transmission of Sounds.—This demands the presence of an elastic medium between the point of production and the ear. In ordinary daily life the tendency of the waves to be transmitted in a straight line and the distance are the more essential factors in modifying the intensity with which they are heard. In physical diagnoses, however, we are chiefly interested in the quality of the intervening substance, for it is chiefly to determine abnormal physical conditions of this substance that we listen to the sounds at all. *Transmission through any uniform medium* varies with the elasticity coefficient, mass, and density of the

individual substance, and in the body we may simply note that bones transmit well and that soft tissues transmit poorly, though do somewhat better if compressed, as when the stethoscope bell is applied with considerable force. *Where the intervening substance is not uniform,* however, a most important though less obvious factor enters—*dispersion.* Sound waves, like the waves of light, radiate in straight lines, decrease in intensity with the square of the distance and traverse certain substances better than others. This similarity is further emphasized by the fact that sound waves may be projected to a given spot when the point of production is at the focus of a parabolic resonator, and that they may be concentrated and focussed by properly constructed lenses of hydrogen. In such experiments the facility with which waves enter or are reflected back from the surface of the second medium depends on the quality of the said medium, and the angle of its surface. And just as a ray of light may be more diminished by passing it through a little ground glass than through many times as thick a layer of clear glass, so sounds that would be readily transmitted a considerable distance in wood are stopped by a thin layer of sawdust. The lack of penetration in each case depends upon the fact that *with each change of transmission medium some of the waves are reflected backward or diverted laterally,* and the intensity suffers accordingly. To limit the intensity of light the absorbing power of colors is so much more practical that the method of

dispersion, as in the use of ground glass, is seldom employed. In the case of sound, however, dispersion is constantly employed, and underlies the use of carpets, padded walls, felt partition, and the like.

PHYSICS OF PERCUSSION.

With these more important laws of physics in mind, we turn now to see how they may explain the sounds obtained by auscultation and percussion.

Percussion consists in tapping upon the chest wall and noting the sounds produced. If we strike any series of miscellaneous objects the sounds evoked depend upon the nature of the substance thus thrown into vibration, and also upon the violence with which it is struck. As the object of percussion is to determine the physical nature of the underlying tissues, it is essential that variations due to *differences in the strength of the percussion stroke must be avoided.*

From a physical stand-point animal *tissues may be divided into bones, soft tissues, and soft tissues containing air.* On tapping, or to use the technical term, "percussing" a bone, we find that it can be made to vibrate and to give forth sounds of an intensity which varies with the force with which it is struck; of a pitch which varies with its size and shape, and of a quality which is sufficiently typical to be recognized from sounds obtained by percussion over other parts of the body. *Bones are resonating bodies,* and their percus-

sion yields a fairly typical sound which we call a bony note or osseous resonance.

Percussion of *soft tissue, whether muscle, fat, liver, etc., on the other hand, yields no resonance.* This absence of resonance, called flatness, is because such tissues have considerable mass but very poor elasticity. *Collections of fluid are equally devoid of resonance* to percussion. Not only do soft tissues yield no resonance, but *they also impede transmission* of the percussion stroke to an underlying resonating body, and impede the return of sound waves from the resonator to the ear. A layer of rubber will muffle the loudest drum.

Percussion of Air-containing Tissues. — Percussion yields its greatest information in dealing with soft tissues containing air. Over a large air-containing cavity the percussion note varies in intensity with the force employed and with the amount of intervening tissue. Therefore when constant force is used, the *intensity enables us to estimate the amount of tissue intervening.* Thus in percussion upward on the abdomen the edge of the liver is detected by the decreased intensity over that part of the stomach, or colon, which it overlies. With very light percussion, just sufficient to produce resonance over the exposed portion of the gut or stomach, the muffling effect of a very thin layer of liver may be detected. In ordinary work, however, the percussion of the lower liver margin is usually made out 2 or 3 cm. higher than the true edge.

On the other hand, the *pitch over such cavities depends*

entirely upon their size. The difference between small intestine and a colon is detected by the abrupt fall of pitch on passing to the larger cavity. Ordinarily the air collections within the body are surrounded by elastic walls under moderate tension, and the sounds obtained by percussion are due to both air content and containing wall vibrating in unison. *Should the air, however, be under high tension, the elasticy of the wall is impaired* so that it has little resonance of its own and also even fails to transmit the vibrations of the air within. Thus, rare cases of pneumothorax in which a valve-like perforation of the lung allows air to enter but not to leave the pleural cavity, may give a dull note, instead of the usual increased resonance. This decreasing resonance, as the pressure within a cavity rises, can be illustrated by percussing the moderately and then the forcibly distended cheek; or better still, a pneumatic tire during inflation.

Another factor occasionally enters into consideration in percussion over cavities. An organ pipe with open ends produces tones of twice the number of vibrations as that of the same pipe with the end closed. The leather bottle of the pool table on percussion is thus found to give a note of lower pitch when its neck is corked. Percussion of the cheek with the lips alternately opened and closed yields the same result. And where a pulmonary cavity communicates freely by a widely open bronchus, this *change of pitch* may again be frequently demonstrated by having the

patient alternately open and close his mouth during percussion.

On percussing a beaker filled with effervescing liquid we obtain a beautiful drum-like (tympanitic) sound; while from a beaker of plain water no note is elicited. The difference is evidently due to the presence of numerous, though minute, air bubbles in the former. Similarly a pan of raised dough ready for baking gives a tympanitic note, quite like that obtained over a moderately tense, inflated bladder of similar size. With this in mind we might expect the normal lung to yield sounds on percussion of the same drum-like, musical character. *On examining the relaxed lung removed from the body this tympanitic note is found,* but on percussing the normal chest a sound of good intensity but entirely different character, called pulmonary resonance (*vide* p. 74), is obtained. That the difference is not due to the chest wall is readily demonstrated by the percussion of a lung removed from the body and then inflated to its original size. This *inflated lung gives, not a tympanitic note, but the peculiar sound called normal pulmonary resonance.* This is because the tissue fibers of the relaxed lung are no more capable of maintaining a vibration than are the slackened strings of a violin; and merely follow the vibrations of the air contained within them. The note obtained over a relaxed lung is therefore identical with that found over the air-containing water or dough—tympanitic and varying in pitch with the size of the organ. On inflation, however, *the stretched*

lung fibers add their own vibrations to those of the air content; and the composite sound elicited is now no longer a drum-like tone, but a non-musical noise, to which, in the absence of any descriptive term, the name normal pulmonary resonance is applied.

It is interesting to note that when the pan of risen dough is baked, the loaf of bread yields no longer a tympanitic note, but a sound very similar to normal pulmonary resonance; because its air content is now subdivided by elastic partitions capable of maintaining vibrations of their own.

The Strength of the Percussion Stroke.—This may influence the sound elicited not only in intensity but also in quality. This does not apply in such simple resonating bodies as tuning-forks or strings. But if a thick-walled box is very lightly struck, we may only set in vibration the immediate superficial layers of the wood, and would therefore be unable to recognize the presence of the cavity within. To detect the latter, sufficient force to set it in vibration must be employed. Therefore in determining the height of the liver dome (liver dulness), where we are contrasting the sound produced by chest wall and a thin layer of lung with that produced by chest wall plus a much deeper layer of lung, the percussion stroke should be forcible enough to arouse vibrations in the deeper tissue. On the other hand, *a heavy stroke sets in motion not only tissues deeper beneath it, but also those over a wider surface.* Even 1 or 2 inches below the right pulmonary border a sufficiently heavy stroke

may spread its vibrations to the distant lung or colon, yielding dull pulmonary resonance or tympany instead of flatness. For this reason in determining the physical condition of superficial tissues light percussion, just sufficient to arouse vibrations in those tissues, is essential.

PHYSICS OF AUSCULTATION OF THE LUNGS.

Transmission of Voice, Whisper, and Breath Sounds Through Solid Tissues.—On listening over the larynx when the patient speaks, loud, clear-cut voice sounds are heard with the words perfectly recognizable. Behind over the cervical vertebræ the same clear-spoken words are audible, though less intense. In either case the sounds are conducted well by the intervening tissue, and differ only in intensity, depending on how great a distance they have had to traverse, but not in any other respect. If we listen over an area of consolidated lung we find that the voice sounds are much the same; still less intense, perhaps, but still clear. The same would be true of whispered words, and of the breath sounds. *The sound vibrations are in all three instancss produced at the glottis; and are transmitted either directly, by the tissues of the neck, or downward first by the air within the trachea, bronchi and bronchioles, and then by the tissue of the consolidated lung, and chest wall.* Although the distance which must be traversed by those vibrations passing downward to the chest wall is much greater, still their inten-

sity is surprisingly well maintained. This is because of the particularly good transmission in their course within the bronchial tubes.

In ordinary cases of consolidated lung the large bronchi remain open so that the vibrations have but a relatively short distance of solid lung to traverse. Should the bronchi be closed with fibrinous exudate, however, as is the case *in so-called massive pneumonia* (*vide* p. 136), *conduction through a much longer distance of solid tissue is necessary* and tremendous loss of intensity results.

According to the thickness of the chest wall the intensity of the sounds is altered for the same reason —because solid tissue is not a particularly good conductor. On the other hand, the sounds may be heard unexpectedly well at the outer end of the clavicle, since bones transmit much better than soft tissue.

Transmission of Glottis-bronchial Sounds through Normal Lung.—The normal alveolar tissue of the lung offers a great obstacle to the transmission of sound waves. The vibrations must pass successively through layer after layer of alternate air and solid. *Great loss of intensity through dispersion results.* The sounds lose in intensity just as if they had to traverse a layer of felt.

Over normal lung the *whisper sounds are practically absent*—their relatively weak vibrations being completely blocked by the alveolar tissue. Voice sounds are far more intense than whisper to start with, and so are able to penetrate to the chest wall, though

modified in two respects. *Voice sounds heard over normal lung are less intense and also have a muffled, humming quality,* quite distinct from the clear-cut sounds heard over a consolidated area. The latter modification is *due to secondary vibrations* set up in the taut-drawn elastic fibers of the alveolar walls, which blur the distinctness of the original sound waves. They may be compared to the added secondary sounds heard on speaking through a paper-covered comb, or on talking into a piano.

The breath sounds over normal lung are very different from those heard at the trachea, cervical spines, or over an area of consolidation. What these differences are will be considered in great detail later (*vide* p. 114). Over consolidated lung we hear the same breath sounds that we hear at the trachea, though less intense because of the distance which the vibrations, produced chiefly at the glottis, must travel in reaching the chest wall. *The normal alveolar tissue, on the one hand, muffles and partially obliterates these glottis and bronchial breath sounds,* just as it blocks off the sound waves of the whispered voice. On the other hand, the *air entering and leaving the alveolar vesicles, and particularly the alternate stretching and relaxing of the elastic framework of those cells, produce the main sound vibrations which we hear* over normal lung. In inspiration the sounds contributed by the alveoli are far more intense. The string that is being stretched is the string that complains. In vesicular breathing the greater intensity of the inspiratory sound seems

wholly of alveolar origin. In expiration, however, the sounds produced in the alveoli are much fainter, and a little of the glottis-bronchial vibrations is frequently audible, particularly when the patient breathes forcibly, or pants.

Infiltration or Partial Consolidation of the Lungs.—This gives so-called bronchovesicular breathing, because the consolidated patches, on the one hand, conduct the glottis-bronchial sounds; while on the other hand, such areas as are normal contribute vesicular sounds to the respiratory murmur which is heard.

Solid Tumor, Cyst or Abscess.—The presence of either of these in the lung modifies the breath sounds, first, by the fact that it replaces the normal lung tissue and therefore prevents the production of vesicular sounds at that point; and second, because the glottis and bronchial vibrations have just so much added solid tissue to penetrate, through which they are not conducted by open bronchioles as in ordinary consolidation. Such conditions, therefore, resemble that of massive consolidation; and, if sufficiently large, obliterate all breath sounds.

A Superficial Cavity in the Lung.—This condition similarly abolishes the alveolar element of the breath sounds at that point. If there is close contact or free communication with the bronchus, the glottis-bronchial voice, breath sound and whisper vibrations are well transmitted; but to them are added the overtones produced by the resonator action that any such air space possesses. *According to the intensity of the*

overtones the sounds heard are called cavernous or amphoric, depending on whether they are more or less musical.

Pneumothorax.—The presence of air within the pleura usually *decreases the intensity of the breath sounds* because the vibrations have one additional layer to traverse. They must suffer the dispersion incidental to passage from tissue to air, and air back to tissue again, before reaching the chest wall. Also the lung upon the affected side is more or less thrown out of function by collapsing against the mediastinum, so that less air is flowing to and fro within its bronchi. Frequently that chest is motionless.

In cases where the communication between the bronchi and the pleural cavity remains widely open, however, the sounds may be intense, consisting of the glottis-bronchial vibrations, which have now no need of passing through an alveolar layer; and also of vibrations produced at the point of connection between bronchus and pleural cavity. But more important than the intensity of breath sounds is the *production of overtones* by the resonator action of the air space, just as occurs in pulmonary cavities; so here extreme grades of amphoric or cavernous voice and breath sounds may be met.

Pleural Effusions.—The presence of fluid within the pleural cavity modifies the signs obtained by auscultation in rather contradictory ways. As will be considered later, the fluid does not lie in a flat layer at the bottom of the chest except in cases of hydro-

pneumothorax. In simple pleural effusions the fluid, though collecting somewhat beneath the lung, rises up laterally so as to also surround the lower portion of the lung, particularly posteriorly. As we cannot examine the diaphragmatic aspect of the thorax, we are especially interested with the effect of the layer of fluid which separates the lung from the chest wall. Moderate collections of fluid, which merely relax the adjacent lung, *decrease the intensity of the breath sounds simply by hindering the passage of their vibrations.* Larger collections, as they compress the adjacent lung, prevent the production of the vesicular element of the breath sounds, and in proportion as they convert the lung into a solid atelectatic state, they abolish the muffling action which normal alveoli exert upon the glottis-bronchial vibrations. Lung which is merely relaxed, but by no means atelectatic, conducts sounds far better than in the distended state; as may be readily verified by listening to a watch through a layer of relaxed and then through a layer of reinflated lung. Though fluid is not a good sound conductor, it is better than distended alveolar tissue, and the glottis-bronchial element of the breath sounds, though faint, are usually audible. The less common occurrence of intense bronchial breath sounds over fluid, more difficult of explanation, is perhaps due to the fluid being in direct contact with an unusually large area of exposed bronchus at the root of the lung, or to complete atelectasis.

ADVENTITIOUS SOUNDS.

Certain physical changes in the lungs caused by disease may merely manifest themselves by alterations of intensity and quality of the respiratory murmur. In two other pathological processes we find on auscultation a new set of so-called adventitious sounds.

Moist Rales.—The most common adventitious sounds are moist rales, due to the presence of serum, mucus, or pus within the bronchial tubes, through which the air entering and leaving the alveoli, bubbles to and fro.

The pitch of these moist rales depends upon the size of the tube in which the bubbling occurs. This may be readily shown by blowing air through a series of different sized rubber tubes containing soap and water, and the imitation is still better produced if the tubes be imbedded in agar, so that the ear or stethoscope may be directly applied to the surface of the latter. Moist rales of high pitch are due to bubbles in the finer bronchioles, while those of the low pitch originate in the larger bronchi.

While the condition of the alveoli is not concerned in the production of moist rales, it may modify their distinctness; just as in the case of other sound vibrations produced in or transmitted downward through the bronchi. Rales produced in the same tubes are muffled when heard through normal alveolar tissue, while they sound sharper and more crackling if their vibrations are better conducted by a consolidated or partially solidified parenchyma. The presence of

consolidation adds nothing to the intensity of the original sound vibrations: it simply conducts those vibrations much more completely to the ear.

Consonating Rales.—An adjacent air-containing cavity within the lung or a collection of air within the pleura (pneumothorax), on the other hand, adds to the original vibrations through its resonator action. The rales in this case are intensified just as are the sounds of fire-crackers exploding within a barrel. In the neighborhood of small and moderate-sized cavities they take on a quality to which the name *consonating* is applied, while near large cavities, and particularly in pneumothorax, the development of overtones is so pronounced that the sounds become beautiful *musical tinklings*.

Dry Rales. — The whistling, piping adventitious sounds called dry rales occur where the lumen of the bronchi is irregularly contracted, either by the presence of tenacious mucus or by actual spasm of the bronchial constrictors. In this case again the pitch depends upon the size of the bronchiole and the degree of contraction. High pitch points to small tubes. Were the decreased size of the lumen uniform there would be no abnormal sound. Air flowing through even moderately irregular tubes does not produce such sounds unless the velocity far exceeds that found within the chest. On the other hand, intense sound vibrations may be produced when air is passed, even at low velocity, through a tube whose lumen is sharply contracted at two or more points;

as may be demonstrated by a glass tube in which two thin perforated corks are inserted; by the well-known button-like whistle consisting of two perforated tin diaphragms separated by a small interval, or by a pill box whose top and bottom have been perforated.

Crepitant Rales.—The so-called crepitant rale is produced within the alveoli and finest bronchioles when their walls, which have become agglutinated either through compression or by the presence of a viscid exudate, are again separated by a deep inspiration. They may be imitated by separating the thumb and forefinger after these have been squeezed together for a few moments. The relaxation of a tightly compressed rubber sponge produces a similar sound.

Pleural Adventitious Sounds.—The simplest of these is the rubbing or crunching sound produced when the roughened surfaces *in dry, fibrinous pleurisy* slide over each other during respiration. Should these surfaces be separated by a layer of intervening fluid no friction sound can occur. It is also to be emphasized that in cases of fibrous pleurisy, the surfaces are again covered by endothelium and friction is not produced. The presence of a pleural rub means that the surfaces are roughened by fibrin and are in contact.

The presence of *air and fluid together* within the pleura (hydro- or pyopneumothorax) gives rise to adventitious sounds caused by splashing of the fluid, either because of movements of the heart or lung within the thorax, or when the patient is shaken bodily (*succussion splash*). The sounds heard are usually musical

and sleigh-bell-like, as the air space is large enough to be very productive of overtones.

In cases of simple pleural effusion, and in those of pure pneumothorax, no sounds are produced within the pleura. *Splashing and dripping sounds can only occur where air and fluid are both present.* The bottle completely filled with fluid is as silent as the bottle which is absolutely empty, shake it as you may.

Analysis of the fundamental notes of the different sounds obtained on auscultation and percussion give the following results (F. Müller):

		Vibrations per second.	Keynote.
Metallic tinkling (overtones)		5000	
		2048	c^4
		1024	c^3
Bronchial voice and breathing		512	c^2
Tympanitic note over abdominal viscera (not pneumothorax)		256	c^1
		128	c
Normal percussion resonance:		120	B
		108	A
	Vesicular breath sounds:	95	G
		85	F
		80	E
		72	D
		64	C
		32	C_1
		16	C_2

The muscular element of the heart sound has a vibration rate of about 60. The valvular sounds and murmurs have a pitch about that of vesicular breathing, *i. e.*, 60 to 160 per second. The vibrations of vocal fremitus have a rate of about 100 per second.

CHAPTER II.

ANATOMICAL, PHYSIOLOGICAL AND PATHOLOGICAL PRINCIPLES INVOLVED IN PERCUSSION AND AUSCULTATION.

Definition of percussion and auscultation—The sounds obtained by these methods of representing healthy and morbid physical conditions—Definition of signs—The basis of our knowledge of signs is the constancy of association of certain sounds with certain physical conditions in health and disease—The present state of perfection of our knowledge of signs furnished by auscultation and percussion—Requirements for the successful study of these methods of exploration—The anatomy and physiology of the chest—An enumeration of the points relating thereto which are of special importance—The physical condition incident to the different diseases of the chest: the conditions relating to the respiratory system stated, and a summary of them—The distinctive characters of healthy and morbid signs; variations in intensity, pitch, and quality, considered as the chief source of the character distinguishing the signs of disease from each other and from those of health—Other distinctions than those of intensity, pitch, and quality—The analytical method of the study of auscultation and percussion—The significance of signs as regards the physical conditions which they severally represent—Morbid conditions, not individual diseases, represented by the morbid signs—Regional divisions of the chest—Anatomical relations of the regions severally to the parts within the chest.

PHYSICAL EXPLORATION.

THE physical examination of the chest embraces six different methods—namely, inspection, palpation, mensuration, percussion, auscultation, and succussion.

Of these percussion, auscultation, and succussion involve the sense of hearing. In percussion the sounds are produced by striking upon the walls of the chest; in auscultation they are caused by acts of breathing, speaking, and coughing; in succussion they are caused by splashing of fluids when the body is shoved abruptly or shaken.

The sounds in auscultation and percussion are (1) normal or healthy sounds, being produced when there is no disease of the chest; and (2) abnormal or morbid sounds, being produced when the chest is the seat of disease. The sounds, healthy and morbid, constitute what are known as physical signs. Frequently, for the sake of brevity, the term signs, without the word physical, is used to denote these sounds. Conventionally, physical signs, or signs, are terms employed in a sense of contradistinction to the term symptoms. The latter term is then restricted to include those abnormal conditions detected by the patient but not objectively demonstrable. The signs are distinguished, of course, as normal or healthy, and abnormal or morbid.

The representation of healthy and morbid physical conditions by certain healthy and morbid signs is established by having ascertained a constancy of association of the signs with the conditions. This constancy of association is ascertained by observation or experience. The sounds obtained by percussion and auscultation in health are thereby established signs of healthy conditions; and the sounds obtained

only in cases of disease are thereby established signs of morbid conditions. Our knowledge of certain sounds as the signs of certain physical conditions can have no reliable basis other than the constancy of the connection of the former with the latter. This constancy of connection is determined by the study of the sounds during life and examination of the organs after death. The existence of certain conditions is not to be inferred from the characters of certain sounds until the connection of the sounds with the conditions has been ascertained by experience; then, and then only, are the sounds to be reckoned as signs of these conditions. So, also, it is not to be inferred from certain physical conditions found after death that certain sounds must have been produced during life, until the connection between the conditions and the sounds has been ascertained by experience. In other words, our knowledge of signs as representing physical conditions, can rest on no other than a purely empirical foundation.

Our knowledge of the signs representing the physical conditions in health and disease, thanks to the labors of Laennec, and of those who have followed in his footsteps, has been brought to great perfection.[1] The practical object of this knowledge is to determine by means of auscultation and percussion, together with the other methods of exploration, the

[1] We owe a debt also to Auenbrugger, who preceded Laennec, and to Wintrich, Skoda, Traube, and Gerhardt, particularly among his successors.

existence of either healthy or morbid physical conditions, and to discriminate the latter from each other; that is to say, the practical object is diagnosis. The signs now known to represent physical conditions, healthy and morbid, taken in connection with symptoms and pathological laws, render, for the most part, the diagnosis of diseases of the chest easy and positive. Hence, it becomes the duty of the medical student and practitioner to give to auscultation and percussion attention sufficient, at least, for their practical application to the diagnosis of the diseases commonly met with in medical practice. In entering upon the undertaking it is important to consider the requirements for the successful study of this province of practical medicine. These requirements relate to: (1) the anatomy and physiology of the chest; (2) the morbid physical conditions incident to the different diseases of the chest; (3) the distinctive character of healthy and morbid signs; and (4) the significance of the signs as regards the physical conditions which they severally represent.

ANATOMY AND PHYSIOLOGY OF THE RESPIRATORY ORGANS.

The necessity of a knowledge of the anatomy and physiology of the chest, as a requirement for the study of auscultation and percussion, together with the other methods of physical exploration, is too obvious to need any discussion. The physical con-

ditions of health must be known as preparatory for appreciating the physical conditions of disease. The student, therefore, who is not acquainted with the anatomy and physiology of the chest, must defer entering upon the study of physical diagnosis until this requirement is fulfilled.

Familiarity with the morbid physical conditions is necessary; and it is advisable to refresh the memory with a review of certain anatomical and physiological points before beginning the study of auscultation and percussion. These points, relating especially to the physical conditions of health, cannot be considered in this work. A simple enumeration of them only can be introduced.

Important anatomical conditions relate to the bones of the chest—namely, the general conformation of the thorax, the differences in respect to the obliquity of the ribs from above downward; the direction of the costal cartilages, their connection with the sternum, and the angles formed by the junction of the ribs and cartilages; the differences in width of the intercostal spaces in the upper, middle, and lower portions of the anterior, lateral, and posterior aspects of the thorax, together with the relations of the scapula and clavicle. The relative thickness of the muscular covering of the chest in different situations is to be considered, and, in women, the varying size of the mammæ. The attachments of the diaphragm to the thoracic walls, and its relations to the organs below, as well as above it, are points of importance (Figs. 5, 6, 7, 8).

Important physiological conditions relate to the parts which the ribs, costal cartilages, sternum, and diaphragm play in the movements of respiration. The differences of these movements in tranquil and in forced breathing; the contrast between the two sexes, and between early and advanced life, are points to be studied. Other points are the frequency of the respirations in health, and the relative duration, rapidity, and force of the inspiratory and the expiratory movements.

Certain anatomical and physiological points pertain to the organs within the chest. The more important of these, relating to normal physical conditions, are the following:

(1) As regards the lungs, the connections of the pleura, and the smoothness of the pleural surfaces in contact with each other; the relations of the apex and base of each lung to the chest walls, and the differences of the two lungs in this respect; the relative spaces occupied respectively by the two lobes of the left, and the three lobes of the right lung; the situation of the interlobar fissures in either side on the posterior, lateral, and anterior aspects of the chest; the arrangement of the air vesicles, pulmonary lobules, and the different-sized intrapulmonary bronchial tubes; the expansion of the air vesicles, and the movement of the current of air from larger to smaller bronchial tubes in the act of inspiration; the vesicles diminishing in size, and the current of air moving from smaller to larger tubes in the act of expiration; the difference in respect to the relative proportion

of air and solids at the end of inspiration and at the end of expiration; the extent to which the volume of the lungs may be diminished by a forced act of expiration, and increased by a forced act of inspiration; the relations of the apices to the trachea, and to the subclavian arteries; and the variable extent to which the apex rises on either side above the clavicle.

(2) As regards the larynx, trachea, and the bronchial tubes without the lungs; the anatomy and physiology of the vocal chords; of the muscles concerned in the movements of respiration and of phonation, with the relations of each to the recurrent laryngeal nerve; the size of the rima glottidis in youth, after puberty, and relatively in the two sexes; the enlargement of the rima in the act of inspiration, the diminution of its size in the act of expiration, and the closer approximation of the chords in the act of coughing; the difference in the amount of areolar tissue above the vocal chords in children and in adults; the situation of the trachea and the point of its bifurcation; the length, direction, and size of the two primary bronchi contrasted with each other, and the branches which penetrate the lungs.

(3) As regards the heart, the boundaries of the space which it occupies—that is, of the precordial space; the relation of the aorta and pulmonic artery to the walls of the chest; the portions of the precordial space in which the heart is covered and uncovered by lung; the situations of the auricles and ventricles respectively; the relations of these to each other, and the arrange-

ments of the valves; the currents of blood through the orifices within the heart, and the relations of each of these to the heart sounds; the rhythmical succession of these sounds; the differences which distinguish each from the other, and the situation in which each has its maximum of intensity; the mechanism of these sounds, and the situation of the apex beat (Figs. 5, 6, 7, 8).

The foregoing are the anatomical and physiological points which especially claim attention with reference to normal physical conditions. It is recommended to the student, before proceeding further, to acquire knowledge respecting all these points, by reference to works treating of the anatomy and physiology of the chest.

THE MORBID PHYSICAL CONDITIONS INCIDENT TO THE DIFFERENT DISEASES OF THE RESPIRATORY SYSTEM.

The various morbid physical conditions incident to different diseases must be known, for it is the immediate object of auscultation, percussion, and the other methods of exploration, to ascertain either the existence or the absence of these morbid conditions. Knowledge of all the important conditions which are deviations from those of health, and the relations of each to different diseases, is therefore an essential requirement.

Deviations from the normal conformation of the chest and the various abnormal movements of respi-

ration, belong properly among the physical signs obtained by inspection, palpation, and mensuration. For the most part these signs represent morbid physical conditions within the chest.

Certain conditions relate to the presence of liquid, either serous, serofibrinous, or purulent, within the pleural sac. The quantity of liquid may be large enough to compress the lung into a solid mass, and to enlarge the affected side, at the same time restraining or annulling the respiratory movements; the chest on the affected side, then, will contain only lung solidified by compression, and liquid. In other cases the quantity of liquid is either small, moderate, or considerable, the lung then containing a lessened quantity of air, and its volume diminished in proportion to the amount of liquid. These morbid conditions are incident to simple pleurisy with effusion, pyothorax or empyema, and hydrothorax.

The pleural surfaces, in cases of pleurisy, may be more or less covered with recent fibrinous exudation, and, when not separated by the presence of liquid, they do not move upon each other smoothly and noiselessly. The friction of the opposed surfaces is still more productive of audible and sometimes tactile signs after the absorption of liquid, when the fibrinous exudation has become more adherent and dense than when it is recent. Should this exudate become organized and its surface covered with endothelium, however, there will, of course, be no friction.

The presence of air in the pleural space, either

alone or with more or less liquid, in pneumothorax, may compress the lung into a solid mass, also dilating the affected side, and restraining or annulling its movements; and the air, with or without liquid, when not in sufficient quantity to produce these effects, may diminish more or less the volume of the lung and the amount of air in the pulmonary vesicles. These morbid conditions give rise to characteristic physical signs. The perforation of lung, usually existing in cases of pneumothorax may become closed as the lung collapses. If, however, a free communication from the bronchi to the pleural cavity remains open, it occasions additional signs which are characteristic.

Solidification of lung is an important physical condition incident to several diseases, irrespective of the condensation, caused by the compression of liquid or air in the pleural sac. Complete consolidation of an entire lobe, or of two and even three lobes, exists in the second stage of lobar pneumonia. Certain physical signs represent this condition of complete solidification.[1] The different degrees of solidification, namely, slight, moderate, and considerable, occur during the stage of resolution in cases of pneumonia, and

[1] The term complete consolidation as used here is not intended to indicate a filling of the large subdivisions of the bronchi with exudate in the affected lobe. This extreme condition may occur and is described as massive consolidation. In this form certain of the physical signs are markedly altered, the breath and voice sounds being diminished or entirely suppressed.

these gradations are represented by well-defined physical signs. Solidification, circumscribed, forming nodules which vary in size and number, situated in the upper, lower, or middle portion of the lung, either on one side or on both sides, exists in phthisis, in bronchopneumonia and collapse of pulmonary lobules, in hydatids, in hemorrhagic infarcts and embolic pneumonia, in pulmonary gangrene, and in primary and secondary neoplasms. It exists, greater or less in degree, in interstitial pneumonia. In these different conditions the existence of solidification, its degree and extent, are determinable by means of physical signs.

A morbid condition the opposite of solidification is an abnormal accumulation of air within the air vesicles of the lungs. This is incident to pulmonary emphysema, involving a morbid dilatation of the air vesicles. The permanent expansion and increased volume of the upper lobes in some cases of this disease occasion a characteristic deformity of the chest, together with abnormal movements of respiration, which are also characteristic. This is represented by distinctive signs furnished by auscultation and percussion. The extravasation of air in the connective tissue, constituting interlobular and subpleural emphysema, in like manner gives rise to signs furnished by these methods of exploration.

The presence of a viscid exudation within the air-vesicles and bronchioles, occurs in acute pneumonia, especially in its first stage, causing the walls of the

alveoli and bronchioles to stick together when emptied at the end of expiration. The separation of these adherent walls, in the act of inspiration, gives rise to an auscultatory sign (the crepitant rale).

An accumulation of serum within the air vesicles constitutes the condition called pulmonary edema. This condition gives rise to signs furnished by auscultation and percussion.

Liquid within the bronchial tubes (serum, pus, blood, or thin mucus) is a condition incident to pulmonary edema, abscess either of the lung, or situated elsewhere and evacuating through the bronchial tubes, phthisis, bronchorrhagia, pneumorrhagia, bronchorrhea, and bronchitis. The passage of air through the liquid in the tubes causes bubbling sounds which are appreciable in auscultation. The apparent size of the bubbles (coarseness or fineness) denotes the size of the tubes in which they are produced, and the pitch of the bubbling sounds denotes either solidification or otherwise of the pulmonary substance surrounding the tubes in which the bubbles are produced.

The presence of tenacious mucus and the swelling of the mucosa in cases of bronchitis may cause diminished calibre of the bronchial tubes in localized or diffuse areas. In cases of so-called capillary bronchitis the condition may involve an alarming degree of obstruction. The same morbid condition is incident to bronchial spasm in asthma, occasioning in this disease great suffering, but without immediate danger. The auscultatory signs enable the auscultator to differen-

tiate the obstruction due to capillary bronchitis from that due to bronchial spasm. Permanent obliteration of more or less of the bronchial tubes is an occasional morbid condition.

Obstruction of a bronchial tube, either within or without the lung, is a morbid condition involving the loss of respiratory sound within the area of the bronchial branches and vesicles not receiving air in consequence of the obstruction. The obstruction may be temporary, being caused by a plug of mucus of sufficient size to prevent the passage of air; the morbid condition is then incident to bronchitis. One of the primary bronchi may be obstructed temporarily by a plug of mucus, and obstruction of the larynx in childhood thus produced may be sufficient to cause death by suffocation. Foreign bodies within the larynx, trachea or bronchi cause similar obstructions. A primary bronchus or the trachea may be pressed upon by an aneurismal or other tumor, and in this way more or less obstruction to the passage of air is produced. However produced, the situation of the obstruction and its degree are, in general, determinable by means of auscultatory signs.

Dilatation of bronchial tubes occasions two morbid physical conditions differing as regards their auscultatory signs—namely, (1) an enlargement of greater or less extent, the tubes preserving their cylindrical form; and (2) a sacculated enlargement. The former occurs generally in connection with solidification around the tubes from hyperplasia of the areolar

tissue, and is thus incident to interstitial pneumonia. The latter when emptied of accumulated secretions may give rise to signs which represent pulmonary cavities.

Sacculated dilatations of bronchial tubes and the cavities incident to phthisis, pulmonary abscess and circumscribed gangrene of lung, are represented by well-marked and highly distinctive signs. The signs denote either that cavities have flaccid walls which collapse in expiration and expand in inspiration, or that, owing to solidification of lung, they remain open during both acts of respiration.

More or less of the space within the chest which, normally, is occupied by lung, may be encroached upon by aneurisms or other tumors, giving rise to notable morbid signs furnished by auscultation and percussion.

Finally, an extremely rare morbid physical condition is the presence of more or less of the hollow viscera of the abdomen within the chest, in consequence of either a congenital deficiency in the diaphragm, or a wound penetrating this muscle (diaphragmatic hernia).

The foregoing morbid physical conditions relate to the respiratory organs. Those relating to the heart are deferred in order that they may precede more immediately an account of the signs of cardiac disease. As a requirement for the study of morbid physical signs the foregoing morbid physical conditions must be understood and memorized.

SUMMARY OF MORBID PHYSICAL CONDITIONS INCIDENT TO DISEASES OF THE RESPIRATORY ORGANS.

1. An accumulation of serous, serofibrinous, or purulent liquid within the pleura sufficient to fill the affected side of the chest, compress the lung, and sometimes causing more or less enlargement.

2. An accumulation of liquid partially filling the affected side of the chest, the quantity being either small, moderate, or considerable.

3. Fibrinous exudation on the pleural surface.

4. Fibrous thickening of the pleura.

5. Air with liquid within the pleural cavity, with or without free communication between bronchus and pleura.

6. Air without liquid in the pleural cavity.

7. Solidification of lung, either complete or approximating to completeness.

8. Partial solidification of lung, slight or moderate in degree.

9. Dilatation of the air vesicles, involving within them an abnormal accumulation of air.

10. Extravasation of air within the pulmonary connective structure.

11. Exudation within air vesicles and bronchioles.

12. Liquid within air vesicles.

13. Liquid (mucus, serum, pus, or blood) within bronchial tubes of large, medium, or small size.

14. Liquid within bronchial tubes of minute size.

15. Obstruction of the pulmonary bronchial tubes by mucus, swelling of the mucous membrane, and spasm of the bronchial muscular fibers.

16. Obstruction of larynx, trachea, or bronchi exterior to the lungs by plugs of mucus or foreign bodies.

17. Obstruction of the trachea or a primary bronchus by aneurismal or other tumors.

18. Dilatation of bronchial tubes, cylindrical or sacculated.

19. Pulmonary cavities.

20. Tumor within the chest, pulmonary abscess, and cysts.

21. Diaphragmatic hernia.

THE DISTINCTIVE CHARACTERS OF HEALTHY AND MORBID SIGNS.

For the practice of auscultation and percussion it is essential to be able to recognize the signs, severally, which represent the different physical conditions in health and disease. The recognition and discrimination of signs require knowledge of the distinctive characters belonging to each of them. In entering upon the study of the signs, therefore, it is a necessary requirement to know whence their distinctive characters are derived. To this point of inquiry the attention of the student is now invited.

The signs being sounds, they are to be recognized and discriminated in the way in which we practically

recognize and discriminate other sounds. In becoming familiar with other sounds, for example, musical notes produced by different instruments, or the varieties of the human voice, we do not have recourse to the science of acoustics. It suffices for all practical purposes to contrast the sounds obtained by auscultation and percussion with reference to very simple and obvious differences. The differences between the sounds obtained by auscultation and percussion relate to intensity, pitch, quality, and duration.

Differences in the intensity of sounds depend upon the size of the vibration waves which reach the ear. One sound is more intense than another sound when it is simply louder, and varying degrees of intensity are expressed by such terms as feeble or weak and loud, to which may be prefixed adjectives of quantity, such as very, moderate, etc.

Differences in the pitch of sounds are easily understood by those who have given any attention to music. They depend upon the rate of vibration of the sounding body. The differences are expressed by the terms high and low. A nice appreciation of variations in the pitch of musical notes requires what is known as a "musical ear;" but this is not essential in comparing, as regards pitch, the sounds studied in auscultation and percussion. For the most part these sounds are not musical notes, and a musician might correctly state that noises have no pitch; nevertheless, differences in pitch are readily perceived. In distinguishing two such noises we are really comparing

the pitch of the lowest tone present in each. A musical ear is undoubtedly an advantage, but it is by no means a *sine qua non.* Differences in pitch now enter pretty largely into the distinctive characters of physical signs;[1] but by Laennec, and those who immediately followed him, comparatively little attention was paid to the study of signs with reference to these differences.

Differences relating to quality are apt, at first, to be confounded with those relating to pitch; hence the distinction between pitch and quality must be clearly understood. We may say of the quality of a sound, that it embraces whatever is not embraced in the terms intensity, pitch, and duration. This is true as a general statement. The sense of the term quality, in distinction from intensity and pitch, may be most readily made clear by an illustration. We recognize at once an unseen instrument by the notes, provided it be one with which we are familiar, such as a violin, a flute, a clarinet, etc. Now, how do we recognize it? Certainly not by the intensity of the sounds; it matters not whether these be loud or weak, so that we hear them. Certainly not by the pitch; for if a piece of music be performed, we get both high and low notes. We recognize the instrument by the quality of the sounds. Each musical instrument,

[1] The contributions of Dr. Flint to this subject cannot be appreciated by those unfamiliar with his essay, "Variations of Pitch in Percussion and Respiratory Sounds, and Their Application to Physical Diagnosis," Tr. Am. Med. Assn., 1852.

owing to its peculiarity of construction, yields sounds which are peculiar to it, depending upon the power of its resonator to intensify special sets of overtones. After we have become familiar with the quality of sounds peculiar to an instrument we immediately thereby recognize it. Precisely in the same way we may recognize certain sounds produced by auscultation and percussion in health and disease. The signs differ in quality according to the physical conditions which they represent; and differences in quality will be found hereafter to constitute essential and obvious distinctions by which the signs of health and disease are recognized and discriminated.

Only by direct observation can one form a definite idea of the peculiar quality of any particular sound. That is to say, no one could clearly describe to another the peculiar quality of a particular sound without the sound having been heard. Imagine the attempt to describe the sound of a violin to a person who had never listened to the notes from that instrument. The only way in which an approximate idea could be conveyed in words would be by comparing the quality to that of some other instrument—that is, by analogy. To attempt to describe the quality of sounds to one who had never heard them would be like describing colors to one blind. It will be seen hereafter that the quality of certain sounds obtained by auscultation and percussion is peculiar to them, and their distinctive characters in this respect can be known only by direct observation.

Appreciable variations in the quality of sounds are infinite. This may be illustrated by the human voice. Almost every person may be recognized from a peculiar quality of the voice by one who is familiar with it; and the voices of thousands of persons, if compared, would present shades of difference. As the diversity in quality of different sounds cannot be described, so they can only be designated by names which are significant from certain resemblances. Terms based on analogies are the following: rough, harsh and rude, soft, blowing, hollow, musical, moist, dry, bubbling, gurgling, crackling, clicking, rubbing, grating, creaking, tubular, cracked metal, sibilant or whistling, sonorous or snoring. All these names owe their significance to resemblances to other sounds. One sound furnished both by auscultation and percussion has a quality which is *sui generis*, and the term used to distinguish it is derived from its source, namely, the vesicular resonance, and the vesicular murmur of respiration.

In addition to intensity, pitch, and quality as sources of the distinctive characters of the signs furnished by auscultation and percussion, there are some other points of difference, namely, the duration of certain sounds; their continuousness or otherwise; their apparent nearness to, or distance from, the ear; their rhythmical succession, and their strong resemblance to particular sounds, such as the bleating of the goat, the chirping of birds, etc. These points of difference are important, although less so than those relating to intensity, pitch, and quality.

The study of these different sounds with reference to intensity, pitch, and quality, distinct signs being determined from points of difference as regards these characters, may be distinguished as the analytical method in contrast with the determination of signs deductively. If we undertake to decide, *a priori,* that certain sounds must be furnished by auscultation and percussion when certain conditions are present we shall be led into error; and so, equally, if we undertake to conclude from the nature of the sounds that they must represent certain conditions. *The only reliable method is to analyze the sounds* with reference to differences relating especially to intensity, pitch, and quality, and to determine different signs by these differences. The import of each of the signs must then be established by the constancy of association with physical conditions.

THE SIGNIFICANCE OF THE SIGNS AS REGARDS THE PHYSICAL CONDITIONS WHICH THEY SEVERALLY REPRESENT.

For the successful employment of the methods of auscultation and percussion, in addition to the recognition of each sign by its distinctive characters, must be known its significance, that is, the physical condition which it represents. The signs furnished by these methods may be said to constitute a language with a very small vocabulary; or, taking as the standpoint the things signified, the different physical conditions are expressed by means of the signs.

The significance of the morbid signs relates, not to diseases, but to the physical conditions incident thereto. *Very few signs are directly diagnostic of any particular disease.* They represent conditions not peculiar to one, but common to several diseases. Thus, solidification of lung exists in pneumonia, phthisis, pleurisy with effusion, collapse, and pulmonary neoplasm; now, certain signs tell us that this morbid condition exists, together with its situation, its degree, and its extent. With this information the diagnosis of the disease is made by connecting with it pathological laws, together with the history and symptoms. The student in physical exploration should by no means imagine that for the diagnosis of diseases exclusive reliance is to be placed on the signs; they are always to be taken in connection with pathological laws, the history, and the symptoms. Disconnected from these the signs would often lead to error, and it is no disparagement to physical diagnosis that its reliability depends on other facts than those which belong exclusively to it.

To repeat a statement already made more than once, the significance of the signs, as regards the conditions which they severally represent, is based on the constancy of their association with the latter, our knowledge of this association being derived from examinations during life and after death.

REGIONAL DIVISIONS OF THE CHEST.

Before entering on the study of physical exploration the student should become acquainted with the divisions of the surfaces of the anterior, posterior,

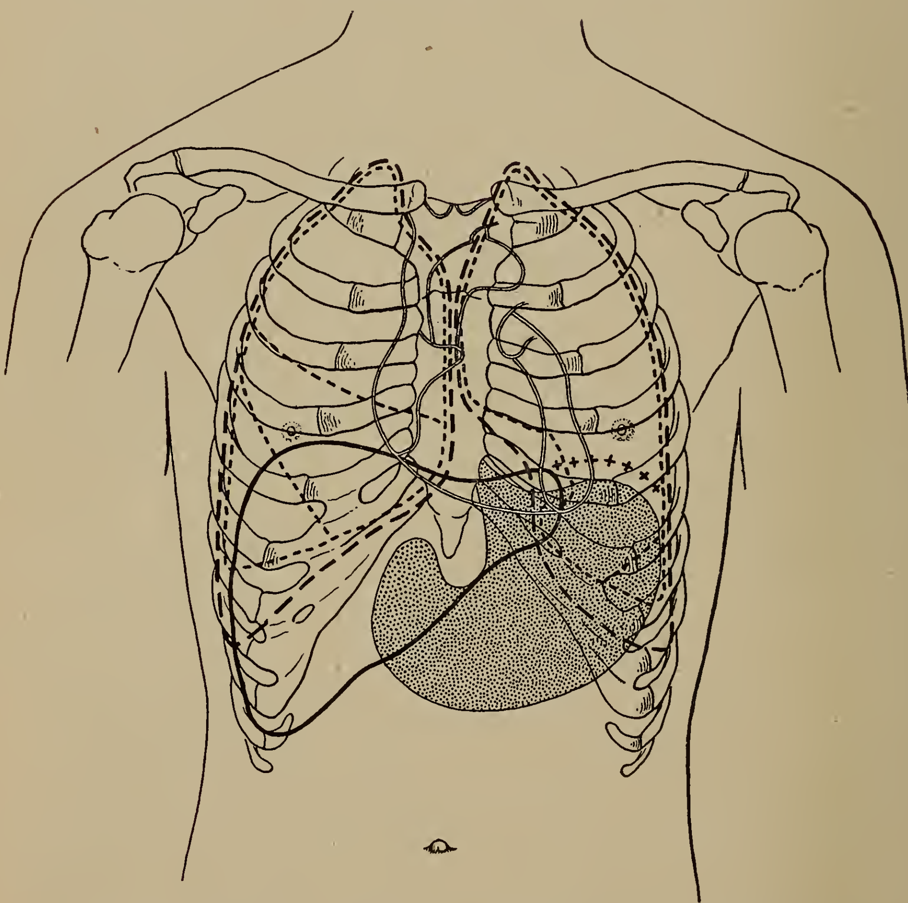


Fig. 5.—Outlines of vicera: Lungs and interlobar lines (dotted line ....); pleura (broken line - - - -); heart and great vessels (double line ═══); liver (solid line ——); stomach shaded. (From Fishberg.)

and lateral aspects of the chest into circumscribed spaces which are called regions.

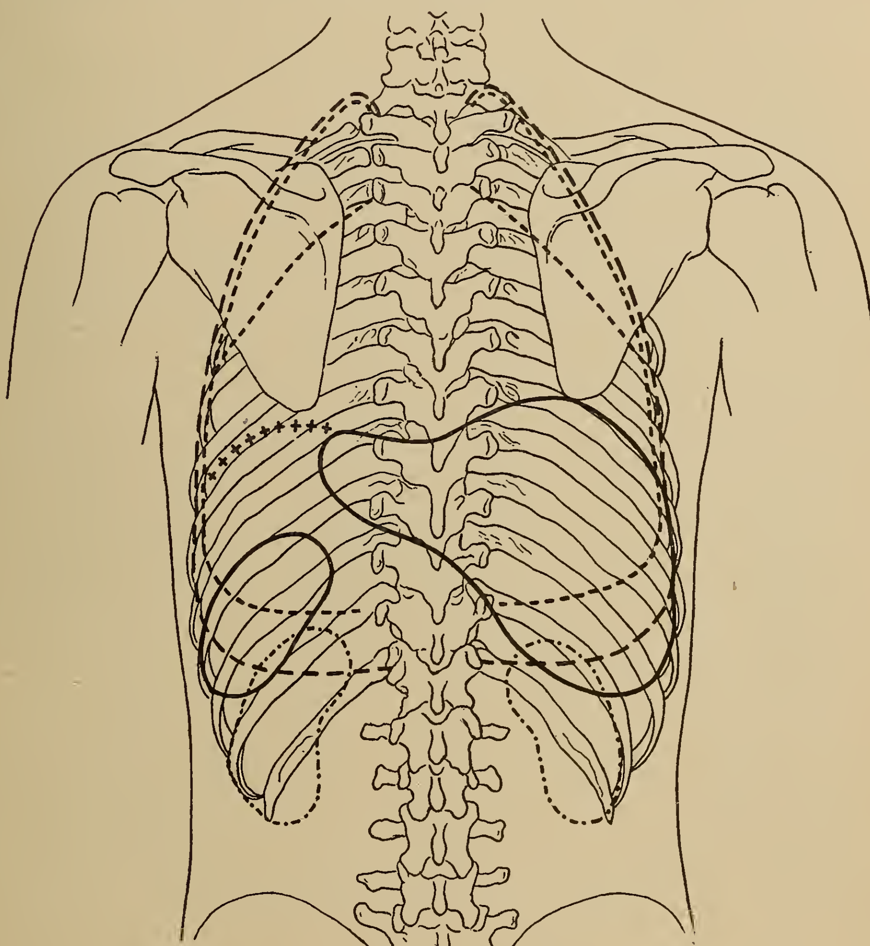
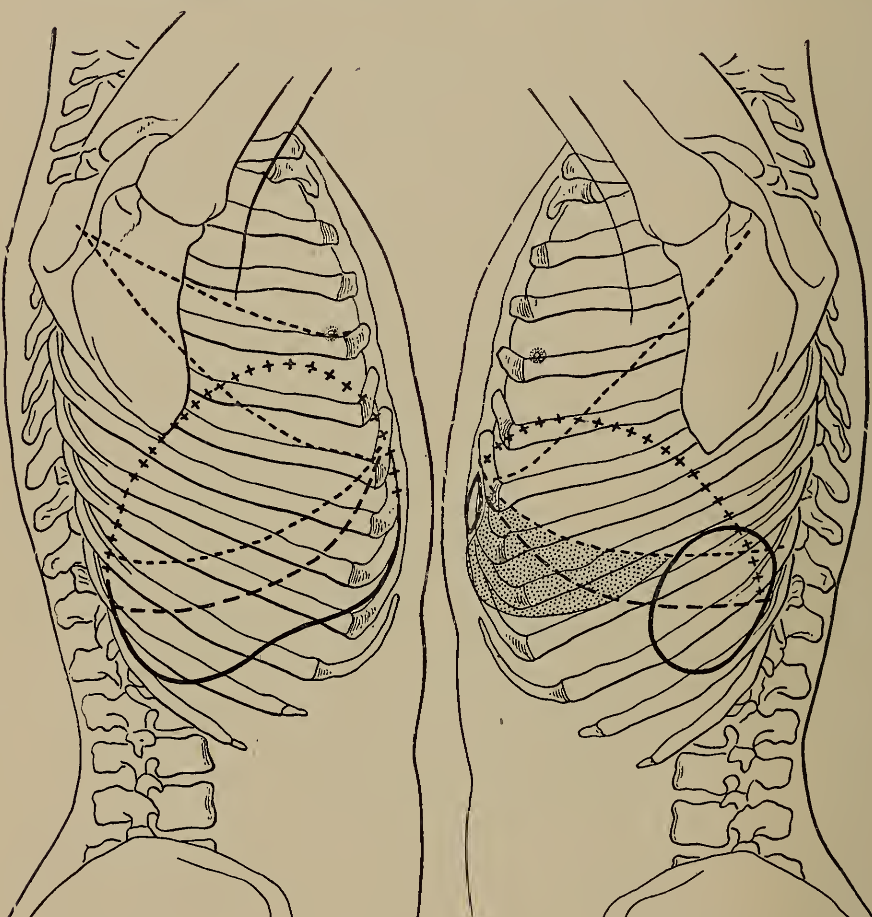


Fig. 6.—Outlines of vicera: Lungs and interlobar line (dotted line ....); pleura (broken line – – – –); liver and spleen (solid line ——); kidneys (dot dash line —·—·—·). (From Fishberg.)

Anteriorly the chest is divided into regions as follows: The supraclavicular region extends from the

clavicle upward a short distance, corresponding to the variable height to which the lung rises above this bone.



Figs. 7 and 8.—Margins of lungs and of individual lobes (dotted line ....); limits of pleura (broken line – – – –); liver and spleen (solid line ——); diaphragm (starred line * * * *); stomach (portion not covered by lung) shaded. (From Fishberg.)

The clavicular region embraces the space occupied by the clavicle. The infraclavicular region extends from

the space between the clavicle to the third rib. The mammary region is bounded above by the third and below by the sixth rib, and the inframammary region is the portion of the chest below the sixth rib.

Posteriorly the divisions are into the scapular, the infrascapular (bases), and interscapular regions. The scapular region is divided by the spinous ridge into the upper and lower scapular space, usually spoken of as the *supra-* and *infraspinous* areas. The *infrascapular* region or base is the portion below a horizontal line intersecting the lower angle of the scapula. The *interscapular* region is the space between the posterior margin of the scapula and the spinal column.

Laterally there are two regions, namely, the axillary and the infra-axillary. The *axillary* region is the space above a horizontal line extending from the lower border of the mammary region, *i. e.*, the sixth rib. The *infra-axillary* region is the portion below the axillary region.

The portion of the anterior surface occupied by the sternum is divided at the third rib into the *upper* and the *lower sternal* region, the space above the sternal notch being the *suprasternal* region.

In order to become familiar with the foregoing regional divisions, it is recommended to the student to delineate them with a skin pencil on the chest of the living subject or a cadaver, and to study sections, extending from the surface to the centre of the chest, so as to become familiar with the relation of each section to the parts contained within it. The more

important of the anatomical relations of the different regions are as follows:

1. **Supraclavicular Region.**—This is relative to the upper extremity or apex of the lung, which arises above the clavicle in different persons from half an inch to an inch and a half. The height is generally greater on one side, and this side is usually the left.

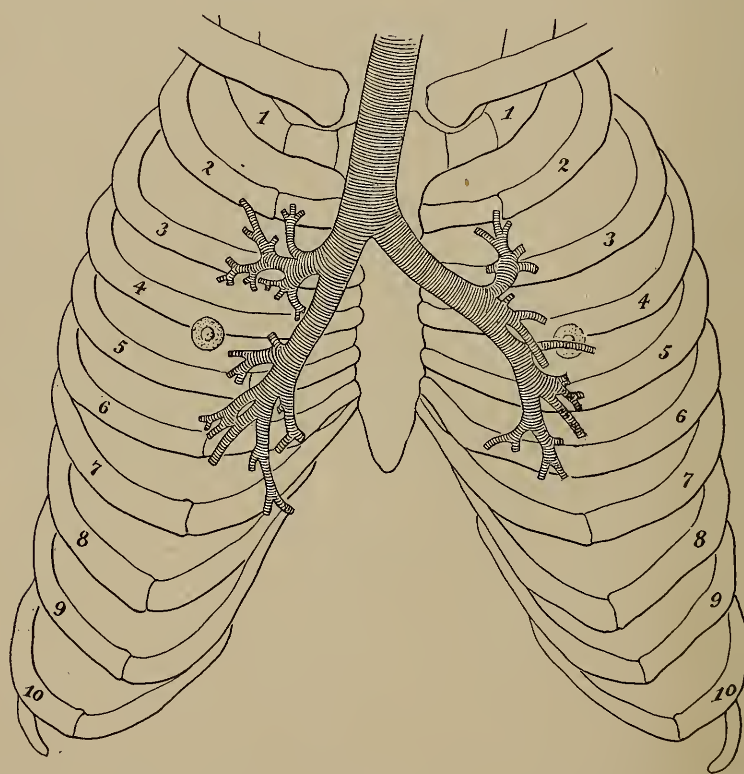


FIG. 9.—Position of the trachea, main and proximal subdivisions of the bronchi in relation to the ribs and sternum.

2. **Clavicular Region.**—A small portion of the lung at or near the apex is contained in this region.

3. **Infraclavicular Region.**—The parts situated here, exclusive of the upper sternal region (*vide* Fig. 5), are the upper portion of the lung, and the extra-pulmonary bronchi. The difference between the primary bronchi, as regards direction, size, and length, are important points in the study of this section (Figs. 9 and 10).

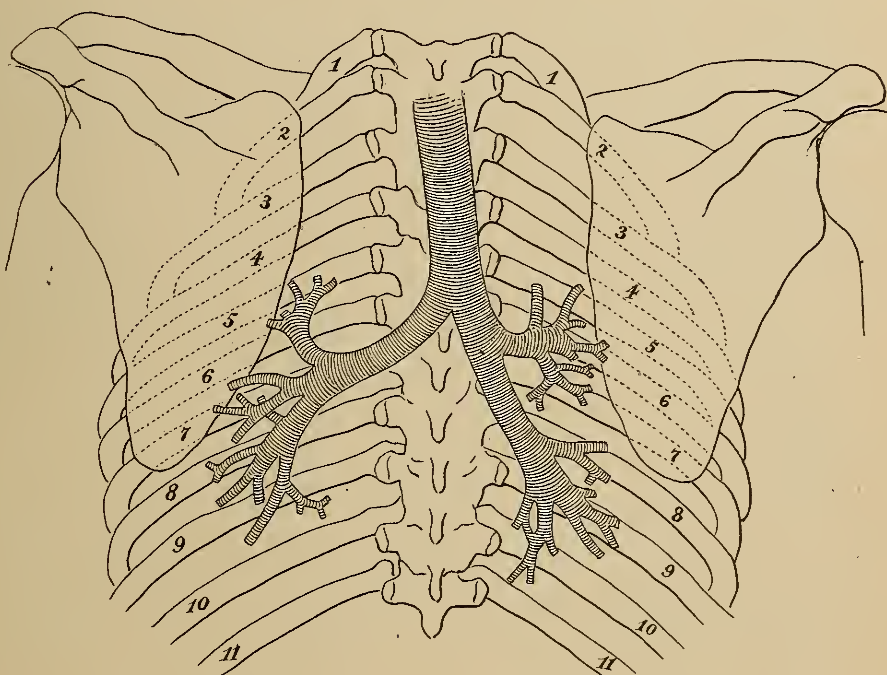


FIG. 10.—Position of the trachea, main and proximal divisions of the bronchi in relation to the ribs and vertebral column.

4. **Mammary Region.**—The differences between the two sides in this region are important. These differences relate especially to the precordia, and are

involved in the physical diagnosis of enlargement of the heart. The commencement of the interlobar fissures is in this region. On the left side the fissure is between the fifth and sixth ribs. On the right side the fissure between the upper and middle lobes begins at the fourth costal cartilage, and between the middle and lower lobes a short distance below. The situation of the fissures, however, differs considerably during the acts of inspiration and expiration. The liver reaches the fifth rib on the right side.

5. **Inframammary Region.**—This region differs in its anatomical relations considerably on the two sides of the chest. On the right side the liver pushes upward the diaphragm nearly or quite to the upper boundary of the fifth rib. On the left side the section corresponding to the region embraces, together with the anterior portion of the lower lobes of the lung, portions of the stomach, spleen, and the left lobe of the liver. The variable volume of the stomach at different times occasions considerable variations in the relative spaces occupied by these different parts.

6. **Suprasternal Region.**—This region is in relation to the trachea.

7. **The Upper Sternal Region.**—The left innominate vein and aortic arch are in relation to the manubrium. The bifurcation of the trachea is beneath the sternum at the centre of a line connecting the second ribs. Below this line the lungs on the two sides are nearly in contact at the midline, covering the primary bronchi.

8. **Lower Sternal Region.**—The sternum in this region covers a large portion of the right and a little of the left ventricle, which lies behind the right in this region.

9. **Scapular Region.**—The sections corresponding to this region contain the posterior portion of the upper lobe and a portion of the upper part of the lower lobe of the lung. At the upper part of the lower scapular (infraspinous) space terminates the fissure separating the upper from the lower lobe. The line of this fissure pursues an oblique course to the fourth or fifth rib on the anterior aspect of the chest. Its course posteriorly is roughly indicated by the vertebral border of the scapula when the hand is placed upon the opposite shoulder with the elbow raised.

10. **Infrascapular Region.**—On the right side the lung extends from the upper boundary of this region to the eleventh rib, the liver lying in contact with the chest wall up to the latter point. On the left side the section contains a portion of the spleen.

11. **Interscapular Region.**—The trachea extends in this section to the fourth dorsal vertebra where it bifurcates.[1] Below this point on the two sides are situated the primary bronchi.

12. **Axillary Region.**—The section corresponding to this region contains a portion of the upper lobe with large bronchial tubes.

[1] The position of the trachea and bronchi in relation to the bony point of the thorax is probably more accurately indicated in the diagrams of Dr. Blake (Figs. 9 and 10) than in the text. Amer. Jour. Med. Sci., March, 1899.

13. **Infra-axillary Region.**—This is in relation to the upper part of the liver on the right side, and on the left side to a portion of the spleen and stomach. The remainder of the section is occupied by lung.

It is recommended to the student to become familiar with the sections corresponding to the different regions, by dissections for this purpose, and the study of anatomical illustrations (Figs. 5, 6, 7, 8, 16, 17, and 23).

CHAPTER III.

PERCUSSION IN HEALTH.

Percussion with the fingers or with a percussor and pleximeter—The normal vesicular resonance on percussion; its distinctive characters relating to intensity, pitch, and quality—Variations in the characters of the normal vesicular resonance in different persons—Relations of the pitch of resonance to the vesicular quality—Tympanitic resonance over the abdomen—Variations of the normal resonance in the different regions of the chest—Enumeration of the regions in which the resonance on the two sides varies, and those in which it is identical in health—Influence of age on the normal resonance—Influence of the acts of respiration on the resonance—Rules in the practice of percussion.

Percussion may be performed with either the fingers or artificial instruments. The fingers suffice for the study and in ordinary practice. Instruments are preferable only when it is desired to produce sounds to be heard at a distance, as in class illustrations, and when, from the number of patients to be percussed, as in dispensary or hospital practice, the frequent repetition of the blows renders the fingers tender and painful. The instruments are a pleximeter and a percussor. A good form of a pleximeter, and of a percussion hammer are illustrated in Figs. 11 and 12.

When percussion is performed with the finger the

palmar surface of one of those of the left hand should be applied to the chest, with pressure sufficient to condense the soft structures, and the blows are given with one or more of the fingers of the right hand bent at the second phalangeal joint so as to form a right angle. In giving the blows the movements should be limited to the wrist-joint, the ends, not the pulp of the percussing fingers, being brought into contact

Fig. 11.—Pleximeter.

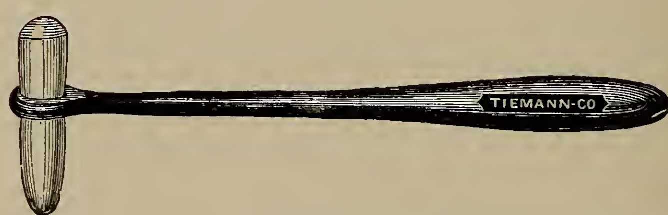


Fig. 12.—Percussion hammer.

with the dorsal surface of the finger applied to the chest. The percussing fingers should be withdrawn instantly the blow is given. The type of perfect percussion is the movement of the hammers when the keys of a piano-forte are struck. The force of the percussion should never be sufficient to give pain to the patient; generally either light or moderately forcible blows suffice. The requisite tact in the performance of percussion is acquired by a little practice.

In percussion for the outlines of viscera lying close to the chest wall, light application of the pleximeter fingers, and a light stroke with the percussion finger gives best results.

In percussion for deeply situated margins of viscera or, for example, areas of consolidation or cavities, the pleximeter finger can with advantage be applied more firmly, and the percussion stroke be slightly more vigorous.

The first object in the study of percussion is to become acquainted with the characters which are distinctive of the sound obtained thereby from the healthy chest. For this object the percussion may be made either in the infraclavicular region of either side, or in the infrascapular region, because the sound in these situations is louder than in other regions. Percussion being performed, a sound or resonance is produced. This sound or *resonance is now to be analyzed with reference to the characters derived from intensity, pitch, and quality.* What are these characters?

The intensity will depend, other things being equal, on the force of the blow; the resonance is comparatively feeble with a slight, and loud with a strong, percussion. Other circumstances affect the intensity irrespective of the force of the blow—namely, the volume of the lung, the elasticity of the costal cartilages, and the thickness of the soft parts which cover the chest. Owing to these circumstances the intensity of the resonance is by no means similar, in the same situation, in all healthy persons. It is comparatively

feeble in some and loud in others. There is nothing distinctive of this normal resonance to be derived from intensity, and we say, therefore, that the intensity is variable.

What is the *pitch* of this normal resonance? The pitch of a sound is always relative; and, comparing this resonance with all the morbid signs obtained by percussion, it is lower in pitch. We say, therefore, that the pitch of this normal resonance is low. The pitch, however, is found to vary in different healthy persons.

What is the *quality* of this normal resonance? It has a quality which is peculiar to it. In this respect it is not identical with any sound produced otherwise than by percussion over healthy lung. The quality can only be appreciated by direct observation. The peculiar quality is due to the fact that the resonance is from air contained in inflated pulmonary vesicles (*vide* p. 28). This quality, which we call *vesicular,* is not equally marked in all healthy persons, being, as a rule, more marked in proportion to the intensity of the resonance.

This vesicular quality, as just noted, is peculiar to the pulmonary resonance. An approximative representation of it is obtained by percussing either a sponge or a loaf of bread. The latter gives a closer imitation than the former. Each of these articles affords a resemblance to the vesicular quality of resonance, for the reason that it contains air in an infinite number of small spaces separated by elastic walls, in

this regard resembling the lungs. In order to represent this sign by percussing a loaf of bread, the loaf should be covered with a napkin, in order to lessen the noise produced by the contact of the finger or the percussor. The upper crust stands in place of the thoracic wall. The resonance elicited illustrates the lowness of pitch with a pretty close approach to the peculiar quality of the normal vesicular resonance.

The *normal resonance, then, may be defined* as: A resonance of variable intensity, low in pitch and having a peculiar quality called vesicular. It is also called the normal resonance, the normal pulmonary resonance, or the normal vesicular resonance. The last of those names is to be preferred.

The normal vesicular resonance on percussion, as has been seen, is not uniform in all healthy persons; not only is its intensity variable, but it varies in pitch and in the amount of vesicular quality. The fact, however, occasions no embarrassment for this reason: *we determine, in each case, that the resonance is normal by a comparison of the two sides* of the chest, percussing in corresponding situations on the two sides, and with the same force. There is no ideal standard of the normal vesicular resonance, but by comparing the two sides of the chest the standard of health proper to each person is obtained. The laws of disease are such that, for all practical purposes, the standard of health is in this way almost always available. Notwithstanding the variations within the range of health, the lowness of pitch and the vesicular

quality are sufficiently distinctive of this normal sign as compared with the morbid signs.

The pitch of the vesicular resonance and its vesicular quality are in a uniform relation to each other; that is, the conditions giving rise to the peculiar quality also render the pitch low; and, conversely, with diminution of the vesicular quality the pitch is relatively higher. This relation will usually be found to hold good in the resonance modified by disease as well as in health.

The pitch and quality of the normal vesicular resonance may be readily illustrated by percussing successively over the chest and the abdomen. Over the latter a more musical resonance of drum-like quality is obtained which is called tympany; depending upon the gas contained within the abdominal viscera. The pitch varies with the amount of gas present but is normally higher than that obtained over the lung. In all these situations, bringing the tympanitic in contrast with the normal vesicular resonance, the peculiar quality of the latter and its lowness of pitch are rendered apparent.

Having studied the characters of the normal vesicular resonance, and become practically familiar with them by percussing different healthy persons, the student should study the variations which this resonance presents in the different regions of the chest (*vide* p. 62) until he thoroughly appreciates that the vesicular quality is independent of the intensity or loudness of the note.

Supra- or Postclavicular Region.—The resonance here varies much in intensity in different persons. The vesicular quality is most marked in the central portions. Toward the sternal extremity the resonance acquires a tympanitic quality from the proximity to the trachea; it becomes vesiculotympanitic. In the supraclavicular region resonance is to be found extending from three-fourths to two inches above the upper border of the clavicle.

Clavicular Region.—Near the sternum the resonance is somewhat tympanitic from the proximity to the trachea. At the central portion the vesicular quality is more or less marked, and the intensity is diminished at the acromial extremity. Throughout the note is slightly modified by having the osseous (tympanitic) note of the clavicle added to the resonance of the underlying organs.

Infraclavicular Region.—The resonance in this region is more intense than elsewhere, except in the axillary and the infrascapular regions. The vesicular quality is combined with a tympanitic quality toward the sternum, the latter being derived from the primary and secondary bronchi.

Scapular Region.—The resonance in this region is notably less intense than in the infraclavicular region, owing to the presence of the scapula and its muscles, though sufficient to be of value in the detection of abnormal conditions in this situation. In proportion as the intensity is less, the vesicular quality is less marked. In the suprascapular region resonance is to

be found for a distance of two to three and a quarter inches along the upper border of the trapezius muscle, a distance which should normally be equal on the two sides.

Interscapular Region.—The resonance in this region is weak in comparison with other regions, except the scapular, owing to the muscles which here cover the chest. Above the resonance is somewhat tympanitic from the relation to the trachea and bronchi.

Mammary Region.—The right and the left mammary regions are to be studied with reference to differences relating to the liver and the heart. On the right side, from the fourth rib downward, the resonance is diminished, because the dome or upper surface of the liver extends up to this height. This *deep liver dulness* is more readily appreciated with rather forcible percussion. At about the sixth rib in the midclavicular line is the lower border of the right lung, and pulmonary resonance is replaced by *liver flatness.* Between the third and fifth ribs on this side near the sternum the resonance is slightly diminished from the presence of a portion of the right auricle and ventricle.

On the left side the resonance is diminished within the precordial space. This space extends vertically from the third rib to the fifth intercostal space; and horizontally from the sternum to a point at or a little within the midclavicular line. The resonance is greatly diminished within what is called the *superficial cardiac space.* This space is represented by a right-angled triangle, the right angle formed by the

median line and a horizontal line intersecting the point of apex-beat in the fifth intercostal space; an oblique line drawn from the centre of the sternum on a level with the fourth rib and the point of apex beat forms the hypotenuse of the right-angled triangle. This oblique line is, in fact, curved, not straight (*vide* Fig. 5, p. 62), the convexity looking to the left side. Practically, however, it is near enough to accuracy to consider it the hypotenuse of a right-angled triangle. Within this space the heart is in contact with the thoracic wall. The resonance obtained, therefore, does not come from lung tissue directly beneath the pleximeter finger, but from diffusion of the percussion vibrations laterally to adjacent lung. The percussion stroke is particularly well transmitted along the costal cartilages and sternum. To determine the superficial cardiac area, the lightest possible stroke should therefore be employed, and even then only the outer portion is demonstrable, because over the sternum a bony note, but no flatness, is obtained. Without this space and within the precordia the heart is covered with lung, and the resonance on percussion is less diminished. It is a useful exercise for the student to determine by percussion the diminution of the area of the superficial cardiac space during forced inspiration.

Aside from the presence of the heart and the convex extremity of the liver, the resonance over the mammary is less than in the infraclavicular region, being diminished by the pectoral muscle, which varies con-

siderably in bulk in different persons; and, in women, by the mammary gland which, however, is never so great as to preclude the useful employment of percussion in this region.

Inframammary Region.—In this region, as in the region above it, the two sides present notable differences. On the right side, over the greater part, and sometimes the whole of this region, resonance is wanting, that is, percussion gives flatness, because no air-containing organ is present. It is easy to delineate the boundary between the lower border of the right lung and the liver, or, as it is called, *the line of hepatic flatness*. It is also easy to distinguish above this line the height to which dulness, due to the dome of the liver extends, or, as it is called, *the line of hepatic dulness.* This line does not correspond to the actual height of the liver dome, as was supposed before the days of x-ray examinations. On the other hand, it is of some diagnostic value; because, with a progressive enlargement of the liver dome, the height of the liver dulness increases. The distance between the two lines is from one to two inches. Both lines are affected considerably by a forced inspiration and a forced expiration. A forced inspiration depresses the line of flatness about one and one-half inch. A forced expiration causes the line to rise from two and one-half to five and one-half inches. The distance, therefore, between this line at the end of a forced expiration and at the end of a forced inspiration varies from four to seven inches. Not infrequently

percussion over the right inframammary region yields a tympanitic resonance due to the distention with gas of the transverse colon.

On the left side the resonance in this region varies in different persons, in the same persons at different times, and in different portions of the region at the same time depending chiefly upon the air content of the stomach. Flatness is caused by the extension of the left lobe of the liver into this region about three inches to the left of the median line.

The left portion of the region is in relation to the spleen, an organ which varies considerably in size in health as well as in disease, its average dimensions being about four inches in length and three inches in width.

The space corresponding to the spleen is determined by the vesicular resonance above and the tympanitic resonance in front and below; the latter boundary, however, not being very reliable on account of the ready conduction of tympanitic resonance for a certain distance. *The spleen lies in the left hypochrondrium between the ninth and eleventh ribs,* its long axis corresponding to the tenth rib. Its posterior extremity is about one and one-half inches from the spinal column; its anterior pole reaches to the middle or at most to the anterior axillary line. The upper posterior third, being covered by lung, is inaccessible to percussion. The remainder, lying against the chest wall, unless forced away by intervening intestines, is found to give a dulness on examination in sitting,

standing, or the right-lateral recumbent position. The lung border, intersecting the eighth and ninth ribs, is the upper limit of splenic dulness; the anterior limit is rarely as far forward as the anterior axillary line; the lower limit is at the eleventh rib; posteriorly the dulness merges into that of the lumbar muscles.

Between the spleen and the liver lies the stomach, the volume of which is constantly fluctuating according to its varying content of solid, liquid, or gas.

A moderate amount of gas is almost invariably present; sufficient, in the recumbent posture at least, to give tympanitic resonance to the area in which the stomach is in contact with the thoracic wall—that half-moon-shaped space between costal arch and lower border of the lung, limited in front by the liver and behind by the spleen, called *Traube's semilunar space.* This space is of considerable importance in the diagnosis of left-sided pleural exudates, which by inserting a layer of fluid in the complemental pleural space, between the stomach and chest wall, decrease or abolish the normal tympany.

Distention of the stomach with gas occasions a tympanitic resonance which is frequently transmitted high into mammary and axillary regions; so high, indeed, that it is occasionally mistaken for pneumothorax

The distention of the stomach with solid or liquid contents, of course, occasions flatness. The study of the inframammary regions with reference to the variations in resonance arising from the organs below

the diaphragm is of much utility from the practice which it involves, and will be of great service to the student in acquiring tact in percussion, and in discriminating differences in the sounds obtained by this method.

Sternal Regions.—In the upper sternal region, that is, above the lower margin of the second rib, the resonance is non-vesicular, being derived from the sternum itself and also from air in the trachea. Being non-vesicular, it is, of course, tympanitic, inasmuch as the resonance is always tympanitic in quality if wholly devoid of the vesicular quality.

Between the second and third ribs, the inner borders of the two lungs approximating, the resonance has a vesicular quality more or less marked; but owing to the remnant of the thymus gland, together with adipose substance, and the presence of the large vessels, the resonance is not intense in this situation.

Below the third rib the resonance has modifications, due to the combination of several different organs situated beneath the lower sternal region. On the right side of the mesial line is the inner border of the right lung, the greater part of the right auricle and part of the ventricle of the heart lying beneath; a portion of the liver extends into the lower part of this region, and a portion of the stomach when distended. The resonance thus varies in different situations, and often presents a mixed character.

The bone of the sternum has a characteristic note of its own which modifies all percussion sounds

obtained upon it, whether there be resonance or extreme dulness.

Infrascapular Regions.—The resonance below the scapula is intense as compared with that over the scapula, and the vesicular quality is marked. The resonance extends to the tenth rib, which is the lower boundary of the lung. At or near this point, on the right side, is the line of hepatic flatness, hepatic dulness extending from one to two inches above this line. The line of hepatic flatness and of hepatic dulness is lowered from one to two inches by a deep inspiration, and raised by a forced expiration. On the left side the resonance may receive a tympanitic quality from the presence of gas in the stomach.

Lateral Regions.—In these regions the resonance is relatively intense and notably vesicular. On the right side the line of hepatic flatness is at the eighth rib, hepatic dulness extending one or two inches above this line. On the left side the resonance may be rendered somewhat dull by the presence of the spleen, but it often has a tympanitic quality from the presence of gas in the stomach.

The Lower Limits of the Lungs.—Allowing for marked individual variations, the average lower limit of pulmonary resonance lies on the *right* side in the lateral sternal line at the fifth and sixth rib, in the mid-clavicular line at the sixth intercostal space, in the midaxillary line at the lower margin of the seventh or upper margin of the eighth rib, in the scapular line at the ninth or tenth rib, near the vertebral column

at the level of the eleventh thoracic spine. On the *left side* the lower limit runs outward from the midsternum behind the fourth rib to the parasternal line, then curving downward to reach the lower border of the sixth rib at the midclavicular line. From that point it turns outward and corresponds to the border on the right.

Standards for the Recognition of Normal Resonance.— As has been stated, the normal vesicular resonance is not in all persons identical as regards intensity, pitch, and quality. There is, therefore, no fixed standard by which we can determine whether the resonance be normal or not. The standard proper to each person is to be ascertained by a *comparison of the two sides* of the chest; each person, in other words, furnishes his own standard of health.

But all the regions do not normally correspond in respect to the resonance on the two sides. In the following regions the resonance is notably dissimilar on the two sides: The mammary, the inframammary, the infra-axillary, and the infrascapular. There is less disparity in the resonance on the two sides in the following regions: The supraclavicular, clavicular, and infraclavicular, the scapular and interscapular, and the axillary. In some of these regions, however, the resonance differs, and it is of practical importance to note the dissimilarity which thus belongs to health. This statement applies especially to the infraclavicular region, a region of great importance with reference to the signs of phthisis. In this region the resonance is

less intense, less vesicular, and higher on the right side. The student should become practically familiar with the normal differences between the two sides.

The normal resonance is affected by age. In early life, when the costal cartilages are flexible and elastic, the resonance is more intense and lower in pitch than in old age, when the cartilages are rigid and the vesicular structure of the lung more or less atrophied.

The ribs and cartilages also effect percussion resonance, depending upon their degree of curvature. The greater the curvature, the more resistance is offered to the percussion stroke, just as the small end of an egg is stronger than the larger. Hence, in the case of a flattened chest, the note in the axilla is less resonant than that obtained in front, even though the lung be normal. This effect of the thoracic wall must be remembered, particularly in the examination of deformed chests, where dulness discovered over a sharply convex area must be decidedly discounted before considering it as proof of pathological change in the lung beneath.

The resonance varies considerably in the different regions at the end of a full inspiration, and at the end of a forced expiration. With regard to this disparity, the following is an extract from a work on physical exploration, published by the author in 1856:

"The percussion sound may also be found to vary at different periods of an act of respiration in the same individual. The quantity of air contained within the air cells, and consequently the relative

proportion of air and solids, are by no means equal after a full inspiration and after a forced expiration. The difference in lung expansion may occasion an appreciable disparity in resonance, according as the percussion is made at the conclusion of a full inspiration or of a forced expiration. The disparity is not appreciable uniformly in different persons. When it does exist, it usually consists, contrary to what might perhaps have been anticipated, and the reverse of what is usually stated in works on physical exploration, in diminished resonance and elevation of pitch at the conclusion of inspiration. This is probably to be explained by the greater degree of tension of the lungs and thoracic walls produced by inspiration voluntarily prolonged and maintained—a condition presenting physical obstacles to sonorous vibrations more than sufficient to counterbalance the increased proportion of air within the cells (*vide* p. 27). It is a curious fact, worthy of notice, that the two sides of the chest are not always found to be affected equally as regards the percussion sound at the conclusion of a full inspiration, contrasted with that after a forced expiration. I have observed the contrast to be more striking on the right than on the left side; and in one instance on the left side the resonance was less intense and somewhat tympanitic after a full inspiration, while on the right side the opposite effect was produced and the sound became quite dull after a forced expiration. In view of these variations in a certain proportion of instances incident to different periods of

a single act of respiration, in some cases of disease in which it is desirable to observe great delicacy in the correspondence of the two sides, pains should be taken to percuss corresponding points at a similar stage of respiration; and the close of a full inspiration is, perhaps, the period to be preferred. Ordinarily, the liability to error from this source is obviated, either by repeating a series of strokes, first on one side and next on the other; or by percussing both sides repeatedly in quick succession, in order mentally to obtain the average intensity and other characters of the sound during the successive stages of a respiration. The instances of disease, however, are exceedingly rare in which such nicety of discrimination is important."

There are two variations in methods of percussion which are found to assist in determining the boundaries of solid viscera and cavities: (*a*) The so-called *auscultatory percussion,* which consists in applying the stethoscope over an area to be outlined, as over the precordium, and then by light percussion (or even delicately stroking or scratching the skin), approaching the stethoscope from all directions, noting the sudden change in intensity of the conducted sound as the border of the underlying viscus is reached. This method is of service also in outlining the borders of the stomach. (*b*) The so-called *threshold percussion* of Goldscheider, which consists in light percussion upon the second phalangeal joint of the bent pleximeter finger, the tip only of the finger being applied to the chest. By using only the interspaces and also

limiting as finely as this the point of application of the stroke, often very precise limits of the heart may be determined.

RULES IN THE PRACTICE OF PERCUSSION.

1. Prior to a comparison of the two sides of the chest, as regards the resonance on percussion, an examination by inspection should be made, in order to determine whether there be any deviation from the normal conformation. In what has been stated, it is assumed that the chest is symmetrical. Any deviation from the normal conformation will affect more or less the resonance in corresponding regions on the two sides (*vide* p. 86). Due allowance is to be made for want of symmetry in determining morbid signs, and often the existence of these cannot be determined with positiveness when there is considerable deformity. The signs obtained by auscultation are less affected by want of symmetry than those obtained by percussion.

2. The position of the person examined is important with reference to the normal symmetry of the chest. If the person be standing or sitting, the position should be upright and the shoulders brought to a level. A little inclination of the body to one side, or a depression of one shoulder, will be found to affect perceptibly the normal resonance when the two sides are compared. If the body be recumbent, it should be as nearly as possible on a level plane. With a patient in the lateral recumbent position, the

side which is uppermost should be examined and the patient then turned to the other side. Otherwise the percussion note of the lower side is modified, not only because of the asymmetry of the chest, but also by resonance contributed from the mattress; so that a reliable comparison between the two sides cannot be made.

3. The person who percusses should be, as nearly as possible, either in front or behind the person percussed. Percussion made by one standing, or sitting, by the side of the person percussed is almost certain to produce disparity in resonance.

4. Percussion made successively on one side and the other side, must be in all respects the same in regard to the force of the blow, the firmness with which the pleximeter finger is applied, and the situation. A light percussion on one side and a strong percussion on the other side will, of course, cause a disparity in the intensity of resonance. The percussion must be made in succession at points as nearly as possible equidistant from the median line, and from the summit or base of the chest. With reference to great nicety, the percussion, if made on the rib or intercostal space on one side, must be made on the rib or intercostal space on the other side. Great nicety also requires that if the percussion be made on one side during the act of inspiration, it should be made on the other side during this act. The signs of disease, however, are generally so well marked that very close attention to these points is not necessary.

5. A series of blows in rapid succession (four or five) is to be preferred to one or two, in practising percussion; difference in intensity, pitch, and quality being thereby better appreciated. For most purposes, however, two or three strokes are sufficient from the stand-point of the examiner, and are much preferred by the patient.

6. Percussion may be made lightly or forcibly, the former being called superficial, and the latter, deep percussion (*vide* p. 29). With light blows the resonance comes from the superficies of the lung and from within a limited area. With forcible blows the resonance is from a greater depth and a wider space. The result of these different modes of practising percussion may be illustrated within the precordia in health. Comparing the resonance over the superficial cardiac space with that in a corresponding situation on the right side, dulness is more marked with light than with forcible blows, the resonance from the latter coming from a wider area. On the other hand, comparing the resonance over the deep cardiac space, dulness is more marked with forcible than with light blows, owing to the presence of lung between the heart and the walls of the chest.

7. Percussion over the anterior portion of the chest, the person percussed leaning against a door, a board partition, or a lathed wall, gives an increased intensity of resonance. It is often useful to resort to this procedure in the practice of percussion.

This very intensity of resonance may lead to error if the patient is examined while lying on a couch which

is equipped with a box-spring. Ignorance of, or inattention to, the resonating cavity beneath the patient may cause confusion in interpreting the signs of percussion.

8. In percussing over the posterior portion of the chest it is important that the scapulæ be drawn forward and downward. By having the patient cross the arms upon the chest, the hands being placed upon the tips of the shoulders and then drawing the shoulders down and bending the head well down upon the chest, the greatest area of the posterior thorax is exposed to examination. Thus the suprascapular and interscapular regions become artificially increased to the great convenience of the examiner. The above procedure is of value when the patient is standing or sitting up in bed. The degree of bending should not be sufficient to materially tighten the muscles, as in that case the chest wall becomes more resistant to the transmission of vibrations.

A position which gives the maximum of muscular relaxation and the greatest exposure of the upper lobes behind may be assumed by the patient while seated on a stool: the body is bent well forward, the head hanging downward and forward upon the chest, and the arms hanging down loosely outside the thighs.

CHAPTER IV.

PERCUSSION IN DISEASE.

Enumeration of the signs of disease furnished by percussion—Requirements for a practical knowledge of these signs—The distinctive characters of the morbid physical conditions represented by, and the different diseases into the diagnosis of which enter the signs, severally, to wit: 1. Absence of resonance or flatness 2. Diminished resonance. 3. Tympanitic resonance. 4. Vesiculotympanitic resonance. 5. Amphoric resonance. 6. Cracked-metal resonance. 7. Unusual changes of tone—Sense of resistance felt in the practice of percussion as a morbid sign.

Percussion in cases of disease furnishes signs which represent the changed physical conditions incident to the affections; with these physical conditions and their relations to pulmonary affections the student is supposed to be familiar (*vide* p. 47 *et seq.*).

The signs of disease furnished by percussion are resolvable into six, namely: (1) Absence of resonance or flatness; (2) diminished resonance or dulness; (3) tympanitic resonance; (4) vesiculotympanitic resonance; (5) amphoric resonance; (6) cracked-metal resonance. The last two named signs are varieties of tympanitic resonance, but it is most convenient to consider them as distinct signs.

Knowledge of these six signs in physical diagnosis requires: (1) A practical acquaintance with the char-

acters which distinguish each from the others, as well as from the normal resonance; and (2) a clear apprehension of the significance of each. That is, we must be able to recognize the signs, on the one hand; and on the other hand, we must be able to interpret them into terms of the physical changes which they represent.

ABSENCE OF RESONANCE OR FLATNESS.

This sign is sufficiently defined by its name. It is absence of resonance or tone. Nothing is heard but the noise of percussion finger striking the pleximeter, such as may be produced by percussing over a solid mass, for example, a limb composed of muscle and bone, or over a collection of liquid, for example, the abdomen in ascites. There being no resonance or tone, the sign has no characters pertaining to pitch or quality. It may be illustrated on the healthy chest by percussing in the right inframammary region below the line of hepatic flatness.

Absence of resonance on percussion over the lungs means simply absence of air in the tissue beneath. This flatness on percussion occurs under four main morbid conditions, namely: (1) The presence of liquid either in the pleural sac or in pulmonary cavities; (2) liquid filling the air vesicles; (3) complete solidification of lung; and (4) a tumor within the chest.

Flatness on percussion always represents one of these morbid physical conditions. Extreme thick-

ening of the visceral and parietal pleura at the base of the lung may give a note so nearly flat that a differential diagnosis cannot be made between thickened pleura and hydrothorax without the use of an exploring needle.

These conditions are incident to different diseases, as follows:

1. Liquid in the pleural cavity is incident to pleurisy with effusion, empyema, and hydrothorax. A collection of pus constitutes pulmonary abscess; and phthisical cavities, or those caused by circumscribed gangrene, may become filled with morbid liquid products.

2. Serous effusion into the air vesicles constitutes pulmonary edema. Liquid blood extravasated characterizes hemorrhagic infarctus, pneumorrhagia, or pulmonary apoplexy. Pus infiltrating more or less of the parenchyma may be derived from an abscess either within the lung or elsewhere, for example, the liver, and from the pleural cavity in empyema when perforation of lung takes place.

3. Solidification of lung occurs in pneumonia from an exudation within the air cells; it is produced by condensation from compression by liquid or air in the pleural sac, the pressure of a tumor, and by collapse; it exists in cases of phthisis, in interstitial pneumonia, and in neoplastic infiltration of lung.

4. Tumors within the chest are of different kinds, for example, aneurisms, primary and secondary neoplasms, echinococcus cysts, and teratomata. In pro-

portion to their size they occupy space belonging to the lung, as well as condensing the latter by pressure. Flatness may also be caused by the encroachment of organs situated below the diaphragm upon the thoracic space, as in cases of enlargement of the liver and spleen, and in massive ascites.

Flatness on percussion in all these conditions is the same. The sign alone does not enable us to discriminate the conditions from each other, nor to determine the existing disease.

Finding this sign present, the particular condition and the disease in each case are to be determined by the situation of the flatness, its extent, the associated physical signs furnished by auscultation, together with the other methods of exploration, and by the symptomatic phenomena.

DIMINISHED RESONANCE OR DULNESS.

The resonance on percussion is diminished, or there is dulness, when the solids or liquids within the chest are morbidly increased without increase in the quantity of air, the increased amount of solids or liquids not being sufficient to cause flatness. Diminution of air without increase of either solids or liquids, as in collapse of pulmonary lobules, also gives rise to dulness. In other words, dulness occurs in the presence of an abnormal proportion of solids or liquids over the air in the pulmonary vesicles.

Dulness varies in degree. It may be slight, mod-

erate, considerable, or great. The degree of dulness corresponds to the amount of the relative disproportion of solids or liquids over the air within the chest.

The pitch of sound is higher than that of the normal resonance of the persons percussed. This is invariable; with dulness there is always more or less elevation of pitch. The quality is altered only in amount; there is, of course, less vesicular quality in proportion as the intensity of the resonance is diminished.

The characters which distinguish this sign, thus, are lessened intensity of resonance, elevation of pitch, and weakened vesicular quality.

The morbid conditions giving rise to this sign are those which, existing in a greater degree, give rise to flatness. Morbid products within the pleural sac, fibrin, serum, pus, lymph, if not sufficient to cause flatness, give rise to dulness. The sign, therefore, occurs in pleurisy, empyema, and hydrothorax. The same is true of pulmonary edema, hemorrhagic infarctus, pneumorrhagia, and purulent infiltration of lung. Solidification of lung, when not complete, occasions dulness; hence, it is a sign in pneumonia, vesicular and interstitial, in phthisis, in condensation of lung from compression, in collapse of pulmonary lobules, and in neoplastic infiltration. A tumor within the chest, not sufficiently large to cause flatness, gives rise to dulness.

There are, however, some conditions giving rise to dulness which are never sufficient to cause flatness. Pulmonary congestion limited to a lobe may diminish

the resonance appreciably. The dulness may exist in the first stage of pneumonia, before solidification from pneumonic exudation has taken place. A layer of fibrin upon the pleural surfaces causes dulness after the liquid effusion in pleurisy has been removed, and after the vesicular exudation in pneumonia is absorbed. Dulness may also be caused by a considerable accumulation of mucus or coagulated blood within the intrapulmonary bronchial tubes.

The particular morbid condition which gives rise to dulness cannot be inferred from the characters of the sign: the sign only denotes that some one of them exists. The condition which exists in each case, and the disease, are to be determined by the situation, extent, and degree of dulness, taken in connection with the information derived from other methods of exploration than percussion, together with the history and symptoms.

TYMPANITIC RESONANCE.

Resonance is tympanitic whenever it is entirely devoid of the vesicular quality; in other words, any *resonance which is non-vesicular is tympanitic.* The leading distinctive character of the preceding sign (dulness) relates to intensity, whereas the leading distinctive character of this sign relates to quality. Tympanitic resonance derives no distinctive character from intensity; it may be either more or less intense than the resonance of health in the person

percussed. This point is to be emphasized, inasmuch as with many the idea of tympanitic resonance involves increased intensity of sound; a resonance, be it ever so feeble, if it be non-vesicular, is tympanitic. If, however, the resonance be quite feeble, it is not always easy to determine whether there be, or not, any appreciable vesicular quality. The term used by Stokes, namely, "tympanitic dulness," is properly enough applied to a resonance with diminished intensity, in which a vesicular quality cannot be appreciated. As regards pitch, a *tympanitic resonance is usually higher than the normal vesicular resonance.* The exceptions to this rule are extremely infrequent. The tympanitic resonance over different parts of the abdomen is always higher in pitch than the resonance over healthy lung.

The following are the morbid physical conditions which give rise to the tympanitic resonance:

1. Air in the pleural cavity. It is, therefore, a sign of pneumothorax. Frequently in this affection the tympanitic resonance is more intense than the resonance of health, the pitch being almost always more or less raised.

2. Pulmonary cavities containing air. It occurs, therefore, in cases of phthisis. In this disease the tympanitic resonance is limited to a circumscribed space corresponding to the site and size of the cavity; whereas in pneumothorax it frequently exists over a considerable part, or the whole, of the affected side of the chest.

3. Complete solidification of the whole or a part of the upper lobe of lung. The tympanitic resonance under these circumstances is derived from the air in the lower part of the trachea and the bronchial tubes exterior to the lungs. This is the explanation of the sign in the second stage of pneumonia affecting an upper lobe, and in certain cases of phthisis prior to the stage of excavation. Dilatation of the intrapulmonary bronchial tubes, with solidification surrounding them, as in some cases of interstitial pneumonia or cirrhosis of lung, may give rise to tympanitic resonance.

4. Conduction of resonance from the stomach or colon containing air or gas. A gastric tympanitic resonance is frequently conducted over a part, and sometimes over the whole, of the left side of the chest. This is more likely to occur when the left lung is solidified. On the right side less frequently a tympanitic resonance may be conducted upward from the colon to a greater or less extent.

Tympanitic resonance may be illustrated by percussion over the hollow abdominal viscera, provided they contain air or gas. The sign may be imitated by percussing an inflated hot-water bottle, or India-rubber balls. The pitch will be found to vary according to the size and the degree of inflation of the bladder or balls. To illustrate this resonance in proximity to a vesicular resonance, one-half of the soft portion of an oblong loaf of bread may be removed, leaving intact

the upper crust. Percussion over this half of the loaf illustrates the tympanitic, and over the other half the vesicular resonance.

VESICULOTYMPANITIC RESONANCE.

This name was proposed by the author many years ago to denote a sign with the following distinctive characters: The resonance is increased in intensity; the quality a combination of the vesicular with a tympanitic, and the pitch high in proportion as the tympanitic quality predominates over the vesicular.

The sign represents especially one morbid physical alveolar condition, namely, a *lessened tension of the elastic alveolar fibers,* which permits the lung tissue to vibrate in union with the air content (*vide* p. 28).

A vesiculotympanitic note is obtained over *pulmonary emphysema* because the parenchyma has gradually lost its tension by stretching. It is also, as a rule, present when the *lung is relaxed by accumulations of fluid* beneath, provided the latter is sufficient to fill one-third, one-half, or even two-thirds of the intrathoracic space. A chest filled with fluid, on the other hand, renders the lung atelectatic and causes flatness on percussion.

The sign is also frequently obtained over the adjacent position of upper lobe when the lower lobe is solidified in the second stage of pneumonia, and over the lower lobe when the upper lobe is solidified.

A loaf of bread may be used to illustrate a vesiculo-

tympanitic resonance, as follows: By means of a hollow cylinder remove longitudinal sections in one-half of the loaf, leaving the crust intact. The spaces thus produced yield a tympanitic resonance, and the portions which surround these spaces give the vesicular resonance. The vesicular and the tympanitic quality are thus combined, with elevation of pitch and increased intensity; over the other half of the loaf the resonance is purely vesicular. Another method of illustrating this sign out of the body is to inflate the human lungs, or the lungs of the sheep or calf. Until the inflation has reached a point somewhat below that of normal lung the percussion note is tympanitic; then with increasing distention it changes to vesiculotympany; and finally to vesicular resonance, when full normal distention is attained.

AMPHORIC RESONANCE.

Resonance is said to be amphoric (a subdivision of tympany) when it has a musical intonation analogous to that produced by blowing over the mouth of an empty bottle. An amphoric sound is easily illustrated by percussing the cheek made tense, the mouth not completely closed, and the jaws separated, as is done when the sound of a liquid flowing from a bottle is imitated. By varying the size of the cavity of the mouth the amphoric sound thus produced may be made to vary much in pitch. This illustration exemplifies the mechanism of the sign in disease.

The sign represents a pulmonary cavity which is generally phthisical. The conditions, aside from the existence of the cavity, are the presence, of course, of air within the cavity, and free communications with the bronchial tubes. These accessory conditions are not constant, so that an amphoric resonance over a cavity is sometimes found, and at other times is wanting. Directly after having been wanting, it may be reproduced if the patient expectorates freely.

When percussion is made with reference to this sign, the mouth of the patient should be open, and one or two rather forcible blows are better than a series of four or six. The amphoric sound may be often distinctly perceived if the ear be brought into close proximity to the patient's open mouth, when the sign is not appreciable otherwise. It may be rendered still more distinct by means of the binaural stethoscope, the pectoral extremity being close to the mouth of the patient.

As a cavernous sign the amphoric resonance is very reliable; but it does not invariably denote a pulmonary cavity. It is obtained in some cases of pneumothorax, if the pleural space communicates freely with the bronchial tubes. It is sometimes obtained over a solidified portion of lung situated in close proximity to a primary bronchus, the resonance being derived from the air within the latter. It is occasionally produced by percussing over the site of the primary bronchus in the second stage of pneumonia affecting an upper lobe. In children, owing to the yielding

of the costal cartilages, it may even be produced in health over a primary bronchus. In all these exceptional instances the associated signs and symptoms will prevent the error of attributing the sign to a pulmonary cavity.

This sign is properly a variety of tympanitic resonance.

CRACKED-METAL RESONANCE.

The name of this sign, expressing an analogy to the sound produced by striking a cracked metallic vessel, denotes its peculiar character. It may be imitated by folding the hands so as to form a cavity and striking them upon the knee, or by forcibly percussing a rubber hand bulb with a rather small opening. In both cases *a composite sound* is produced, consisting in the tympanitic note of the cavity to which is added a short hiss, as some of the air is forced out from between the palms or through the neck of the bulb. Like the sign last described, it is a variety of tympanitic resonance.

The cracked-metal, like the amphoric, resonance represents generally a phthisical cavity. Percussion is to be made in the same way as for the production of the amphoric resonance, and, like the latter, the cracked-metal character is often best perceived if the ear, or, better still, the stethoscope be brought close to the patient's mouth.

The cracked-metal and the amphoric resonance are often associated; and the exceptional instances

already mentioned in which the latter is produced, without the existence of a pulmonary cavity, will apply equally to the former.

THE WINTRICH, WILLIAMS, AND GERHARDT PHENOMENA.

If a patient who exhibits a *vesiculotympanitic* note or tympany over a cavity communicating freely with a bronchus, opens his mouth during percussion the pitch of the note is raised. This is called Wintrich's *change of pitch,* or Wintrich's phenomenon. When this phenomenon occurs where there is infiltrated or contracted lung tissue but no cavity, it is called *Williams's tracheal tone.* This may be illustrated by percussion of the cheek or larynx with the lips alternately closed and opened. If the pitch of a tympanitic note over a cavity changes with the patient's position we speak of this change as Gerhardt's tone change or phenomenon. It indicates a change of the shape of the resonating chamber, owing to the shifting of fluid on change of position.

SENSE OF RESISTANCE.

In addition to the acoustic phenomena produced by percussion with the fingers applied to the chest instead of a pleximeter, an abnormal *sense of resistance* is felt in certain conditions of disease. In health, with a somewhat forcible percussion, the walls of the chest are felt to yield in proportion as the costal cartilages are flexible.

This yielding is diminished or ceases when a collection of liquid in the pleural cavity, or liquid in the air vesicles, and solidification of lung, offer a mechanical obstacle thereto. An abnormal sense of resistance on percussion, thus determinable by comparison of the two sides of the chest, is a sign representing some one of the morbid physical conditions just named. On the other hand, in pneumothorax one of the most suggestive signs, though incapable of demonstration to others, is the extraordinary springiness of the chest wall. The appreciation of resistance comes only after practice, but when acquired is of very real assistance. This properly belongs among the signs obtained by palpation.

CHAPTER V.

AUSCULTATION IN HEALTH.

Importance of the study of the auscultatory sounds in health —Immediate and mediate auscultation—Advantages of the binaural stethoscope—Rules to be observed in auscultation—Divisions of the study of auscultation in health—The normal laryngeal and tracheal respiration—The normal vesicular murmur; its distinctive characters, and the variations in the different regions on the same side, and in corresponding regions on the two sides of the chest—The normal vocal resonance—The laryngeal and tracheal voice and whisper—The normal thoracic vocal resonance and fremitus; the distinctive characters of each: the variations in different regions on the same side, and in corresponding regions on the two sides of the chest—The normal bronchial whisper, with its variations in different regions on the same side, and in corresponding regions on the two sides of the chest.

The term auscultation, when dealing with the respiratory system, denotes the act of listening to the normal and abnormal sounds produced by respiration, voice, whisper, and cough.

The study of auscultatory sounds in health is essential as preparatory for the study of auscultation in disease. The student must be familiar with the normal sounds before undertaking to become acquainted with those which represent morbid conditions. Ample time and attention should be given to the study of auscultation in health; until the student is familiar not

only with the sounds heard over a typically normal chest, but also with the rather wide variations of those sounds which are still consistent with normal lungs beneath. The omission to do this is a frequent cause of difficulty and want of success in attaining to a satisfactory proficiency in physical diagnosis. Moreover, as will be seen, some of the most important of the morbid signs have their analogues in certain normal sounds pertaining to the respiratory system.

Auscultation is either immediate or mediate. It is *immediate when the ear is applied directly to the chest,* which may be either denuded or covered with a cloth or clothing. It is *mediate when the sounds are conducted to the ear by means of an instrument* called a stethoscope. The student should practice both immediate and mediate auscultation. The direct application of the ear to the chest suffices for diagnosis in many cases of disease; but there are sometimes objections to this by the patient on the score of delicacy, and by the auscultator on the score of the uncleanliness of the person examined. There are certain parts of the chest which can only be explored by the stethoscope, and this instrument has the advantage of circumscribing the space whence the auscultatory sounds are derived. Moreover, by means of the stethoscope, which is to be preferred over the great variety of instruments heretofore in use, the sounds are usually heard much better than by immediate auscultation. Immediate auscultation, however, is sometimes of the greatest value in the detection of very soft bronchial

breathing and in the recognition of certain faint high-pitched cardiac murmurs. It is also useful in appreciating the strength of the apex beat, or the pulsation over aneurisms, although this belongs properly to palpation.

Stethoscope.—The stethoscope which is to be preferred conducts the sounds into both ears, that is, it is binaural. In this consists its great superiority. An instrument must fit the individual examiner, or it is without value. The knobs which are to enter the ears must be of the right size; if they enter too far they occasion pain. The curves at the aural extremity must be such that the aperture is in the direction of the meatus of the ear. The flexible tubes must not be stiff, and their movements must be noiseless. All the tubes must be unobstructed, for it is the air within the tubes which conducts the sounds; and they must be sufficiently thick to exclude sounds arising outside the patient. In the use of the instrument it should be applied to the chest without any intervening clothing.

The use of the binaural stethoscope is so universal and the types are, on the whole, so similar that it seems out of place in the present edition to discuss the matter in detail. The selection of the chest-piece, whether large or small, funnel or bell-shaped, is a matter for the individual physician to decide according to his need and use, merely noting, according to the shape of the bell, certain pitched sounds are better or more poorly heard. The flat chest-piece used in the Bowles phonendoscope is convenient in examining the posterior

regions of the chest, in patients so ill in bed that the chest cannot be made easily accessible in all its parts.[1]

Rules for Auscultation.—The rules to be observed in the practice of auscultation, in health and disease, may be here introduced.

In auscultation, as in percussion, *corresponding situations on the two sides* of the chest are to be explored successively, and compared. When the stethoscope is used, the pectoral extremity must be applied on each side with the same degree of pressure; this is especially essential in the comparison of vocal sounds. In immediate auscultation the ear is to be applied with a certain degree of force, and a thin layer of clothing does not interfere materially with the perception of auscultatory sounds. The ear not applied to the chest may or may not be closed by the finger in listening to the respiratory sounds; it should be closed in listening to the vocal sounds, in order to prevent confusion from attention to the voice from the patient's mouth. In immediate auscultation, whenever practised, the auscultator should take a position which will not interfere with the sense of hearing, and not occasion a feeling of discomfort. These difficulties are in the way of auscultating with the body bent forward; the sense of hearing is dulled by the detention of blood in the head, and the position

[1] The makes of stethoscopes provided by Tiemann and Ford, in New York, and the Gannett model, formerly used largely in Boston and Baltimore, are reliable. The Bowles phonendoscope is made by Pilling & Sons, of Philadelphia.

cannot be maintained without discomfort. The person examined, if practicable, should be sitting, and the position for the auscultator is that of kneeling on one knee, and lowering, if necessary, the body, so that the head may be kept upright. These points are less important if the binaural stethoscope be used.

When listening to respiratory sounds, it is generally desirable that the person examined should breathe with somewhat greater force than in ordinary breathing; but it is important that the normal rhythm of respiration should be unchanged. Persons when requested to breathe with increased force are apt to err in breathing violently, and frequently with considerable noise produced in the nose or mouth. The readiest mode of obtaining what is desired, is for the examiner to illustrate it by his own breathing. A complete expiration is important in order to secure a satisfactory inspiration. It should therefore be made clear by explanation and illustration that each expiration should be finished before the following inspiration.

The ability to abstract the mind from thoughts and sounds other than those to which the attention is to be directed, is essential to success in auscultation. All persons do not possess equally this ability, and herein is an explanation in part of the fact that all are not alike successful. To develop and *cultivate by practice the power of concentration* is an object which the student should keep in view. Generally, at first, complete stillness in the room is indispensable for the study of auscultatory sounds; with practice,

however, in concentrating the attention, this becomes less and less essential.

The study of auscultation in health embraces the following:

1. The sounds produced by respiration as heard over the larynx and trachea, or the *normal laryngeal and tracheal respiration.*

2. The sounds heard over the chest in the acts of respiration. These sounds, coming chiefly from the air vesicles, constitute what is called the *normal vesicular murmur.*

3. The resonance heard over the chest, and the vibration or thrill produced by the loud voice, or the *normal vocal resonance and fremitus.*

4. The sounds heard over the chest with the whispered voice, or, inasmuch as these sounds are conducted chiefly by the air in the bronchial tubes, the *normal (bronchial) whisper.*

These four normal signs will be considered in the foregoing order.

NORMAL LARYNGEAL AND TRACHEAL RESPIRATION.

For all practical purposes the laryngeal and the tracheal respiration may be considered to be identical, that is, the shades of difference between the sounds in these two situations are not of importance as regards the application to physical diagnosis. The laryngeal respiration is more readily studied than the

tracheal, and for the study of each the stethoscope is necessary.

Applying the stethoscope over the side of the larynx, the person examined breathing with some increase of force, but without any alteration in rhythm, a sound is heard with each of the two acts of respiration. The inspiratory and the expiratory sound, studied separately and contrasted with each other, have the following characters relating to intensity, pitch, quality, duration, and rhythm: The *inspiratory sound* is of variable intensity. In ordinary breathing it varies much in different persons, and in different acts of breathing in the same person. It is always intensified in forced breathing. The pitch is high when compared with the inspiratory sound as heard over the chest. The quality of the sound is well defined by the word tubular; the sound at once suggests a current of air through a tube. The duration of the sound is from the beginning to nearly, not quite, the end of the inspiratory act. The characters of the inspiratory sound, thus, are more or less intensity, a high pitch, a tubular quality, and a duration a little less than that of the act of inspiration.

An *expiratory sound* is always heard with forced breathing. As regards duration, it is as long as, or longer than, the sound of inspiration. In general it is more intense than the sound of inspiration. The pitch is higher than that for the inspiratory sound. The quality is the same as that of the inspiratory sound, namely, tubular.

8

Repeating the characters distinctive of the normal laryngeal respiration, they are as follows: The inspiratory sound is of variable intensity, high in pitch, and tubular in quality. The expiratory sound is as long as, or longer than, the inspiratory sound; it is higher in pitch, and usually more intense. Owing to the inspiratory sound not continuing quite to the end of the inspiratory act, there is a very short interval between the two sounds. In this latter point consists the only variation between the rhythm of the acts of breathing and that of the sounds.

The foregoing characters should not only be verified by the student, but he should become so familiar with them by practice that it requires no effort of the mind to recollect them. It is especially desirable that he listen over the sixth and seventh cervical vertebræ where the sounds will be found much decreased in intensity, but otherwise identical with those heard anteriorly. For at the very outset he is too often merely impressed with the loudness of laryngotracheal breathing, instead of appreciating its more important qualitative characters. It will be seen hereafter that these characters of the normal laryngeal respiration are precisely those which distinguish an important morbid physical sign, namely, the bronchial or tubular respiration.

NORMAL VESICULAR MURMUR.

This is the name usually given to the respiratory sounds heard over the different regions of the chest.

These sounds should be studied with the ear applied directly to the chest (immediate auscultation), as well as with the stethoscope. In commencing the study the middle of the anterior surface of the chest on the right side, to avoid the sounds of the heart, or still better, the posterior aspect below the scapula on either side should be selected. The person examined should breathe somewhat more forcibly than in ordinary breathing, but not violently nor quickly, nor too slowly, the normal rhythm being unchanged. The mouth should be open and care taken to avoid the production of sounds from the nose or teeth. Children are better than adults for this study, owing to the greater intensity of the murmur in early life.

The characters which belong to the inspiratory and the expiratory sound in the normal vesicular murmur are as follows: "The *inspiratory sound* is of variable intensity. There is a wide variation in different healthy persons. In some persons it is so feeble as scarcely to be appreciable even with the binaural stethoscope. The pitch of the sounds, compared with the inspiratory sound in the normal laryngeal or tracheal respiration, is notably low. The quality of the sound is peculiar; no distinct idea of the quality can be formed by any comparison, although it roughly resembles the rustling of wind in the trees. The name used to designate the quality is *vesicular*, this name only denoting that the air vesicles are in some way concerned in the production of the sound (*vide* p. 32). This vesicular quality must be impressed

upon the perception and memory by direct observation. The duration of the inspiratory sound is from the beginning to the end of the inspiratory act.

"An *expiratory sound* is not always, although generally, appreciable. It is much less intense than the sound of inspiration. It is notably lower in pitch than the sound of inspiration. The quality of the sound is neither vesicular nor tubular. It may be called simply a blowing sound, and may be imitated by blowing with the mouth partially opened. The duration is much shorter than that of the inspiratory sound, occupying only the earlier portion of the act of expiration."

The characters, thus, which distinguish the normal vesicular murmur are, an inspiratory sound variable in intensity, low in pitch, and vesicular in quality; an expiratory sound less intense than the inspiratory, still lower in pitch, non-vesicular and non-tubular, or simply blowing; the inspiratory sound continuing from the beginning to the end of the respiratory act, and the expiratory sound beginning with the expiratory act but ending before this act is completed, its duration, relatively to the inspiratory sound, being variable, but averaging about a fifth. The inspiratory sound continuing to the end of inspiration, and the expiratory sound beginning with the act of expiration, it follows that there is no interval between the two sounds. It is to be remarked that an interval is not infrequently produced by the person examined holding the breath after inspiration is

completed. This variation in the rhythm of the acts, of course, produces a corresponding variation in sounds of breathing.

The characters of the normal vesicular respiration may be studied by inflating the lungs removed from the human cadaver, or from the sheep or calf, and applying the binaural stethoscope directly upon the pulmonary surface. In this experiment the vesicular quality is strongly marked. In the same way the tracheal respiration may be studied and its characters contrasted with those of the vesicular respiration. This readily available method is strongly recommended for the study of the normal respiratory signs.

Having become familiar with the characters of the normal vesicular respiration as compared with those of the normal laryngeal or tracheal respiration, the student may then proceed to study the former in the different regions of the chest. The murmur will be found to present variations in the different regions on the same side, and in the corresponding regions on the two sides of the chest. The variations, within the range of health, in the latter are especially important. The following account of the murmur in the different regions embodies the results of the analysis of a series of recorded examinations of healthy persons.[1]

Right and Left Infraclavicular Region.—The murmur in this region, on either side, differs more or

[1] Flint, Tr. Am. Med. Assn., 1852, vol. v.

less from the murmur as heard in the anterior regions below, or in the infrascapular region. The vesicular quality in the inspiration is less marked. The pitch is higher. The expiratory sound is longer, less feeble, and higher in pitch. The difference between the two sides in this region is especially important with reference to diagnosis. The intensity of the inspiratory sound is almost invariably greater on the left side. Its vesicular quality is more marked, and the pitch is lower. *Per contra,* the inspiratory sound on the right side in this region, is less intense, less vesicular, and higher in pitch than the inspiratory sound on the left side. In forced breathing the intensity of the murmur is increased more on the left than on the right side. The expiratory sound is sometimes wanting on the left, when it is heard on the right side. On the right side, the expiratory sound is longer than on the left side. It may be prolonged on the right side to nearly or quite the length of the inspiratory sound. Sometimes on the right side the pitch of the expiratory is higher than that of the inspiratory sound on the same side, and it may have a tubular quality. A rare peculiarity is a prolonged, high, tubular expiratory sound on both sides, analogous to the laryngeal or tracheal expiration. When this is the case the pitch of the expiratory sound is higher on the left than on the right side.

The most reasonable as well as the most recent explanation for the differences in the respiratory sounds in the right and left infraclavicular regions,

and an explanation which seems to be based on the best understanding of the problem, is one given by Fetterolf.[1] He ascribes the difference in intensity and character of the sounds on the right side to the fact that the trachea is throughout practically its entire thoracic course in contact with the right upper lobe, while it is separated from the left lung by 3 cm. or more of large bloodvessels, and esophagus with areolar and lymphatic tissue. It is this intimate relation with the trachea which seems to account for the greater length of the expiratory sound on the right side as well as for the other characteristic differences.

These modifications of the respiratory murmur in the infraclavicular region are marked in proportion as the sounds are studied near the sternum, that is, over the site of the primary bronchi. The respiratory murmur in this situation has been called the normal bronchial respiration, from its resemblance to the morbid sign so named. It may be more properly called a vesiculotubular, or the normal *bronchovesicular* respiration, the characters being those of the morbid sign to be described in the next chapter.

In the diagnosis of diseases, especially of phthisis, due allowance must be made for the points of disparity which exist normally between the two sides of the chest in the infraclavicular region. Without a practical knowledge of these points of disparity, error in diagnosis can hardly be avoided.

[1] Arch. Int. Med., 1909, iii, No. 1.

Right and Left Scapular Region.—As compared with the infraclavicular region, the respiratory murmur heard over the scapula is feeble, because of the thickness of the tissues; and the vesicular quality is less marked. On the right side the inspiratory sound is generally weaker and the pitch higher, while the expiratory sound may be prolonged and is more constantly heard than on the left. Compared with the left side, the murmur on the right thus may have vesiculotubular or bronchovesicular characters more or less marked.

Right and Left Interscapular Region.—In the upper and middle portions of this region the normal characters are the same as in the sternoclavicular portion of the infraclavicular region. The same points of disparity between the two sides are more or less marked here as they are anteriorly over the site of the primary bronchi.

Right and Left Infrascapular Region.—The intensity of the murmur is greater than over the scapular region. In most persons there is no notable disparity between the two sides; when a disparity exists the intensity is greater and the pitch lower on the left side. A prolonged, high-pitched, bronchial expiratory sound is sometimes transmitted below the scapula on the right side.

Right and Left Mammary Regions.—The inspiratory sound in these regions (from the third to the sixth rib) is less intense than in the infraclavicular region; the vesicular quality is more marked, and the pitch is lower. An expiratory sound is often wanting.

Right and Left Axillary and Infra-axillary Regions.—The inspiratory sound in these regions is as intense as in any portion of the chest. The intensity is less in the infra-axillary than in the axillary region, and the pitch is lower. In some persons the murmur on the two sides presents no disparity, but in other persons the vesicular quality is somewhat more marked and the pitch is lower on the left than on the right side. An expiratory sound is oftener heard than in the mammary regions.

NORMAL VOCAL RESONANCE.

Laryngeal and Tracheal Voice and Whisper.—Applying the stethoscope either over the broad surface of the thyroid cartilage, or just above the sternal notch, and requesting the person examined to count with a moderate intensity of voice, the auscultator perceives a strong resonance, with a sensation of concussion or shock, and a sense of vibration, thrill, or fremitus. The voice seems to be concentrated and near the ear. The articulated words are transmitted so as to be heard more or less distinctly. The laryngeal or tracheal voice thus embraces different elements, namely: (1) The vocal resonance; (2) the concentration and nearness to the ear; (3) the vibration, thrill, or fremitus; and (4) the transmission of the speech, the latter corresponding to pectoriloquy. These different elements will be found to enter into the distinctive characters of morbid vocal signs.

Whispered words occasion little or no shock or thrill but an intense, high-pitched tubular sound, with a sensation as if a current of air were directed into the ear through the stethoscope. This sound corresponds to the sound of expiration in laryngeal or tracheal respiration; the two sounds are, in fact, identical if, as is the case with some exceptions, the person whisper with the expiratory breath. Articulated words are transmitted with more or less distinctness, thus corresponding with the morbid sign called whispering pectoriloquy.

Normal Thoracic Vocal Resonance and Fremitus.—The vocal resonance over the chest is to be studied both by means of the stethoscope and by immediate auscultation. In the latter the ear not applied to the chest should be closed in order to exclude the entrance of sound from the mouth of the person examined. When the stethoscope is employed, care must be taken, in making a comparison between the two sides of the chest, or between different regions on the same side, that the pectoral extremity of the instrument be pressed with an equal amount of force against the chest. The intensity with which the vocal resonance is transmitted is much affected by the degree of pressure with the stethoscope.

The situations in which the student should commence the study of the normal vocal resonance are those selected for beginning the study of the normal vesicular murmur, namely, the middle of the anterior aspect of the chest on the right side, and below the scapula behind.

With the stethoscope or the ear directly applied in the situations just named, the person examined should be requested to count "One, two, three," in a uniform tone and with moderate force. The examiner should himself pronounce these numerals, in order to show the manner of counting. This is far better than asking a question and studying the resonance during the answer of the person examined. The objection to the latter mode is that the attention of the examiner is divided between the characters of the thoracic resonance and the idea conveyed by the answer.

The characters of the vocal resonance in these situations are as follows: The voice is heard with an intensity which varies very much in different persons; in some the resonance is feeble, and it may be almost inappreciable, while in others it is quite intense. The intensity depends greatly on the loudness and lowness in pitch of the voice of the person examined, and is therefore weaker in women than in men. It is rarely attended with a sense of concussion or shock. It is diffused; that is, it does not seem to be concentrated like the tracheal or laryngeal vocal resonance. It evidently comes from a certain distance; that is, the sound does not seem to be near the ear. Impression of the distance of the sound is highly distinctive of the normal resonance as compared with a morbid vocal sign (bronchophony).

The resonance is accompanied by a sense of vibration, thrill, called *vocal fremitus,* the intensity of which,

like the resonance, varies much in different persons. This fremitus is properly not an acoustic but a tactile sign, due to vibrations of so low a rate as to be appreciable to the sense of touch. Vocal fremitus belongs properly to the method of physical exploration called palpation. It is, however, appreciated by the ear in immediate auscultation, and may be studied in connection with vocal resonance.

From the foregoing characters the normal vocal resonance may be defined as muffled, lacking in distinctness of articulation, distant, variable in intensity, and accompanied with more or less vibration, thrill, or fremitus.

Having become practically familiar with these characters of the normal vocal resonance in the situations in which they are first to be studied, the next object of study relates to the normal variations in the different regions on the same side of the chest, and in corresponding regions on the two sides, as in the study of the variations of the respiratory sounds (*vide* p. 117 *et seq.*).

Infraclavicular Region.—The *vocal resonance* in this region on either side is more intense than in the anterior regions below. Irrespective of intensity, it is less diffused, nearer the ear, and the pitch is somewhat higher. These latter variations are marked chiefly in the sternoclavicular extremity of the region, that is, over the site of the primary bronchi. In some persons the concentration, nearness to the ear, and elevation of pitch, especially on the right side, are such as to

approximate to the morbid sign called bronchophony, which will be considered in the next chapter. It is important to know that exceptionally this may be, in a measure, illustrated in health in the infraclavicular region. The resonance may then be termed normal bronchophony.

The vocal resonance on the right side is invariably greater. The degree of difference between the two sides varies in different persons. The resonance may be more or less marked on the right and nearly wanting on the left side. Allowance is to be made for the points of normal disparity between the two sides in the diagnosis of disease; hence, the student must become practically familiar with them.[1]

The *vocal fremitus* varies fully as much as the vocal resonance in different persons. Its intensity is not always proportionate to that of the resonance; that is, the resonance may be comparatively weak when the fremitus is strong, and *vice versa*—simply depending upon the proportion between the slow vibrations appreciable to touch and the more rapid ones appreciable to the sense of hearing. The fremitus, like the resonance, is always greater on the right than on the left side, the disparity, like that of the resonance, varying considerably in different persons.

Scapular Region.—The resonance in this region is notably less intense than in the infraclavicular region. It is also more diffused and distant. The intensity

[1] For explanation, *vide* p. 119. (Fetterolf, Arch. Int. Med., 1909, iii, No. 1.)

is always greater on the right side. The same is true of the vocal fremitus and is simply due to the thickness of the intervening tissues.

Interscapular Region.—The intensity of the resonance here is nearly or quite as great as in the sterno-clavicular extremity of the infraclavicular region. The resonance has in some persons in this region the characters of bronchophony. The intensity is always greater on the right side. The fremitus is more or less marked, and always more marked on the right than on the left side.

Infrascapular Region.—As a rule the resonance in this region is stronger than over the scapula. It is always characterized by diffusion and distance. As in all the regions, it varies much in different persons, and is stronger on the right than on the left side. These statements are also applicable to fremitus.

Mammary and Inframammary Regions.—The resonance is notably less than at the summit of the chest. The characters of bronchophony are never present. The intensity is greater on the right side. The same is true of fremitus.

Axillary and Infra-axillary Regions.—The resonance in these regions, and especially in the axillary region, is greater than over the mammary and inframammary regions. It is, of course, stronger on the right side. The characters as contrasted with those of bronchophony, namely, distance and diffusion, are marked. Fremitus is more or less marked, and, of course, more marked on the right than on the left side.

NORMAL WHISPER.

Prior to the publication of the author's work on the *Physical Exploration of the Chest,* in 1856, signs in health and disease relating to the whispered voice had received but little attention. It was his privilege to appreciate the importance of this sign, and emphasize its value in diagnosis. As a point of departure for the study of the morbid signs thus obtained, of course the signs in health must first be studied.

It will facilitate the study of the normal whisper, as well as of the morbid signs, to consider that the characters of the sounds produced with the whispered voice are identical with those produced by the act of expiration, in all respects save intensity. Whispered words are produced, as a rule, by an act of expiration, the sounds being more intense generally than those which accompany even forced breathing. Curiously enough, there are exceptions to this rule. Some persons insist upon whispering with the act of inspiration, and there are some persons who have never acquired the ability to whisper. It will be at once evident that the pitch and quality of sounds, produced by whispered words with the act of expiration, must be the same as those of the sounds of expiration in breathing.

Selecting for the study of the normal whisper the same situations as in commencing the study of the normal respiratory murmur, and the normal vocal resonance—namely, the middle of the chest in front, on the right side, and the infrascapular region behind;

with the whispered voice in these situations is heard, in most persons, a feeble, low-pitched, blowing sound, these characters corresponding to those of the expiratory sound in forced breathing. The normal whisper in these situations is not in all persons appreciable.

In the infraclavicular region the whisper is heard, with variable intensity, in most persons. It is somewhat higher in pitch than the whisper below this region. It is louder and higher in the sternoclavicular than in the acromial extremity. In the former situation it has not infrequently a tubular quality. It is louder on the right than on the left side of the chest. It is sometimes heard on the right when it is inappreciable on the left side. When heard on both sides the pitch of the sound is higher on the left than on the right side. It will be observed that these variations correspond to those of the sound with expiration in the infraclavicular region (*vide* p. 117). Occasionally whispered words are partly transmitted, constituting incomplete whispering pectoriloquy.

In the scapular region the whisper is not infrequently wanting. It may be present on the right and not on the left side, and if present on both sides it is always louder on the right side.

In the interscapular region, as a rule, it is nearly or quite as marked as over the site of the primary bronchi in front. The pitch is more or less high, and has a tubular quality. It is louder on the right and higher in pitch on the left side, and in this situation there may be incomplete whispering pectoriloquy.

In the infrascapular region it is frequently audible. When present it is generally feeble, the pitch being low and the quality non-tubular or blowing. It is oftener wanting on the left than on the right side, and, if present on both sides, it is louder on the right side.

In the mammary and inframammary regions it is not infrequently wanting, and the statements just made with reference to the infrascapular region are alike applicable to these, as, also, to the axillary and infra-axillary regions.

CHAPTER VI.

AUSCULTATION IN DISEASE.

The respiratory signs of Disease—Abnormal modifications of the normal respiratory sounds—Increased vesicular murmur—Diminished vesicular murmur—Suppressed respiratory sound—Bronchial or tubular respiration—Bronchovesicular respiration—Amphoric respiration—Cavernous respiration—Bronchocavernous respiration—Vesiculocavernous respiration—Shortened inspiration—Prolonged expiration—Interrupted respiration—The vocal signs of disease—Bronchophony—Whispering bronchophony — Egophony — Increased vocal resonance — Increased bronchial whisper—Cavernous whisper—Pectoriloquy—Amphoric voice or echo—Diminished and suppressed vocal resonance—Diminished and suppressed vocal fremitus—Metallic tinkling—Signs obtained by acts of coughing, or tussive sounds—Adventitious respiratory sounds, or rales—Laryngeal and tracheal rales—Moist bronchial rales: coarse, fine, and subcrepitant—Dry bronchial rales—Vesicular or crepitant rale—Cavernous or gurgling rale—Pleural friction rales, metallic tinkling and splashing—Indeterminate rales.

The auscultatory signs of disease, which are to be considered in this chapter, should not be studied until the student has made himself complete master of all the characters belonging to the normal signs obtained by auscultation. For our criterion for the detection of disease by auscultation consists merely in the recognition of sounds modified beyond the limits of normal variations.

Auscultation in disease embraces the signs produced by respiration, voice, whisper, and by acts of coughing. The respiratory signs will be first considered.

THE RESPIRATORY SIGNS OF DISEASE.

The morbid signs produced by respiration may be classified as follows: (1) Those which are abnormal modifications of the normal respiratory sounds; (2) those which have no analogues in health, being entirely new or *adventitious sounds.* The latter are usually embraced under the name rales.

ABNORMAL MODIFICATIONS OF THE NORMAL RESPIRATORY SOUNDS.

In order to appreciate the distinctive characters of the abnormal breath sounds, the characters which distinguish the normal vesicular murmur must be kept in mind. The modifications which characterize these morbid signs relate to intensity, pitch, and quality of sound, together with certain alterations in rhythm. Twelve signs are included under this heading, namely: (1) Increased vesicular murmur; (2) diminished vesicular murmur; (3) suppression of respiratory sound; (4) bronchial or tubular respiration; (5) bronchovesicular respiration; (6) cavernous respiration; (7) bronchocavernous respiration; (8) vesiculocavernous respiration; (9) amphoric respiration; (10) shortened inspiration; (11) prolonged expiration; (12) interrupted respiration.

These signs are to be studied (1) with reference to their distinctive characters contrasted with the other morbid respiratory signs as well as with the normal vesicular murmur; and (2) with reference to the morbid physical conditions which they severally represent, that is, their diagnostic significance.

Increased Vesicular Murmur.—This sign has but a single distinctive character, namely, increase of intensity. The murmur is abnormally loud, the characters of the normal vesicular murmur being in other respects not materially changed, that is, the pitch is low and the quality vesicular as in health. Now, it has been seen (*vide* p. 115) that the intensity of the healthy murmur varies much in different persons. There is no ideal standard of normal intensity by reference to which an abnormal increase is to be determined. Yet the increase under certain conditions of disease is such that the fact is sufficiently evident.

It occurs on the healthy side of the chest when the respiratory function on the other side is annulled or much compromised by disease. This takes place in cases of pleurisy with large effusion, pneumonia, especially if more than one lobe be affected, obstruction of one of the primary bronchi, and in pneumothorax. The sign does not possess greater diagnostic importance inasmuch as the nature and extent of the disease are ascertained by the signs obtained on the affected side.

The sign has been called *compensatory* and *puerile* respiration.

If the murmur be much intensified, it may possibly

be mistaken for other morbid signs, namely, bronchial or bronchovesicular respiration. This error, however, can never be made if the distinctive characters of these signs relating to pitch and quality have been correctly studied.

Diminished Vesicular Murmur.—The intensity of the vesicular murmur may be, on the one hand, diminished, although unaltered in other respects; and the murmur, on the other hand, may become so feeble that characters aside from the intensity are not determinable.

The murmur is more or less weakened in cases of dilatation of the air cells, or vesicular emphysema, in which the quantity of the tidal air is decreased in proportion to the volume of the lungs; while gradual giving way of the lung elastic tissues has resulted in the fibers being put under less than normal tension by the act of inspiration. The sign in these cases is often accompanied by changes in rhythm, namely, a shortened inspiration and a prolonged expiration.

Simple weakness of the murmur may also be incident to partial blocking of the air vesicles and bronchioles with blood or serum in cases of pulmonary extravasation and edema.

A deficient expansion of the chest, either on one side or on both sides, occasions weakness of the respiratory murmur. Deficient expansion of one side, or of both sides, may be caused by paralysis, bilateral or unilateral, of the costal muscles. A similar effect is caused by paralysis of the diaphragm. The incomplete descent of the diaphragm from pain, as in peri-

tonitis, or from mechanical obstacles, as in peritoneal dropsy, pregnancy, and abdominal tumors, weakens the respiratory murmur, the increased action of the costal muscles not being fully compensatory. Unilateral deficiency of expansion of the chest is caused by pain in intercostal neuralgia, pleurodynia, acute pleurisy, and pneumonia; it is also caused by the presence of a stratum of liquid, air, or a thick layer of lymph, between the lung and the chest wall in pleurisy, hydrothorax, and pneumothorax. Swelling of the bronchial mucous membrane in bronchitis affecting the larger tubes, must diminish somewhat the intensity of the murmur. In primary bronchitis the murmur is diminished on both sides. In bronchitis affecting the smaller tubes the murmur is greatly diminished, if not suppressed, on both sides. Incomplete obstruction of bronchial tubes from the presence of mucus, serum, blood, or pus, has this effect over an area corresponding to the size of the tubes obstructed. Spasm of the bronchial muscular fibers in paroxysms of asthma, diminishes, if it does not suppress, murmur on both sides. Another cause of diminution, unilateral or within a limited space on one side, is the presence of a tumor pressing on bronchial tubes, as in cases of aneuryim. A permanent contraction or stricture of bronchial tubes is another cause. Not infrequently the pressure of an aneurismal tumor or an enlarged bronchial gland on a primary bronchus occasions notable weakness of the murmur over the whole of one side; and the pressure of a tumor on the trachea weakens the mur-

mur, more or less, on both sides. A foreign body in one of the primary bronchi weakens it on one side. Diminution of the calibre of the trachea or larynx from morbid growths, the presence of foreign bodies, fibrinous exudations, accumulations of mucus, submucous infiltration, spasms of the laryngeal muscles, and swelling of the mucous membrane, weakens, in proportion to the amount of obstruction, the murmur on both sides without any material change in its quality and pitch.

Weakened murmur at the summit of the chest, without other appreciable abnormal characters, occurs in some cases of phthisis, due to obstructed bronchial tubes from coexisting circumscribed bronchitis, or to deficient superior costal movements of the chest, as well as to the presence of exudation in the air vesicles.

Diminished intensity of the vesicular murmur is thus seen to be a respiratory sign entering into the diagnosis of a considerable number of diseases, namely, emphysema, paralysis affecting the respiratory muscles, asthma, abdominal affections interfering with the diaphragmatic movements, intercostal neuralgia, pneumonia, fibrinous pleurisy, hydrothorax, bronchitis, aneurismal and other tumors, permanent constriction or stricture of bronchial tubes, laryngitis, edema of the glottis, spasm of the glottis, the various lesions which occasion obstruction of the larynx or trachea, and phthisis.

In determining a slight abnormal weakness of the respiratory murmur at the summit of the chest on

the right side, the normal disparity between the two sides in this situation is to be borne in mind. The vesicular murmur is normally less intense on the right than on the left side.

This sign occurring in so many diseases, it is obvious that, taken alone, that is, independent of other signs, it has no special diagnostic significance. It is, however, often of value in diagnosis, when taken in connection with other signs. It is chiefly useful when it exists either over the whole or in a part of the chest on one side.

Suppressed Respiratory Sound.—Absence of all respiratory sound, as the name signifies, cannot, of course, have any characters relating to intensity, pitch, and quality.

Suppression of respiratory sound *represents the same physical conditions as diminished vesicular murmur;* the physical conditions represented by the latter sign, existing in a greater degree, occasion absence of all sound. It suffices, therefore, to recapitulate the various conditions and diseases in connection with which the murmur may either be diminished or suppressed. Suppression over portions of the chest may be due to dilatation of the air cells in cases of emphysema. It occurs from the exclusion of air from the vesicles by the presence of blood and serum in cases of pulmonary extravasation and edema. Respiratory sound is sometimes wanting over lung solidified in cases of pneumonia and phthisis when the exudate has occluded the bronchial tubes (massive consolidation).

Paralysis of the muscles concerned in respiration may possibly involve feebleness of the respiratory acts sufficiently to render the murmur inappreciable. In intercostal neuralgia, pleurodynia, acute pleurisy, and pneumonia, the movements of the affected side may be so much restricted as to abolish the murmur. In pleurisy with much effusion, empyema, hydrothorax, and pneumothorax, the murmur is suppressed over either a part or the whole of the affected side, the extent of the suppression corresponding to the quantity of serum, pus, or air within the pleural cavity.

Swelling of the mucous membrane in cases of bronchitis affecting the larger bronchial tubes is never sufficient to suppress the murmur, but plugging of more or less of the tubes with mucus or other morbid products may have this effect. In cases of bronchitis, the murmur is sometimes found to have disappeared over a certain area, and to return after an act of expectoration. In bronchitis affecting the smaller tubes, suppression of the murmur is not infrequent. It occurs from spasm of the bronchial muscular fibers in cases of asthma. The pressure of a tumor, morbid growths, or deposits from bronchi, within the lungs, may abolish respiratory sound over a portion of the chest, and permanent stricture or obliteration of bronchial tubes must have this effect. Respiratory sound may be suppressed over the whole of one side from the pressure of an aneurismal or some other tumor upon one of the primary bronchi. If the tumor

press upon the trachea, the obstruction may be sufficient to suppress the murmur on both sides. A foreign body lodged in a primary bronchus may suppress the murmur on one side, and, lodged in the larynx or trachea, the murmur may be suppressed on both sides. The different affections of the larynx and trachea which, in proportion to the amount of obstruction, weaken the murmur, may render it inappreciable.

Bronchial or Tubular Respiration.—The analogue of this sign is the normal laryngeal or tracheal respiration (*vide* p. 112). The characters which distinguish the latter normal sign from the normal vesicular murmur, are those which are distinctive of the bronchial or tubular respiration. These characters, relating to the inspiratory and expiratory sounds, are as follows: *The inspiratory sound is* of variable intensity. Intensity does not enter into the distinctive characters of this sign; the sound may be either louder or weaker than the inspiratory sound in health. The pitch of the inspiratory sound is high. The quality is expressed by the term tubular; it is like the sound produced by blowing through a tube, this quality taking the place of that expressed by the term vesicular in the normal respiration. *The expiratory sound* is prolonged; it is as long as, or longer than, the sound of inspiration, and is usually louder. The pitch is still higher than that of the inspiratory sound. The quality, like that of the inspiratory sound, is tubular, this quality taking the place of the simple blowing quality of the expiratory sound in the normal vesicular

murmur. With the normal rhythm of the respiratory acts there is a very brief interval between the sounds of inspiration and expiration, due to the fact that the inspiratory sound ends a little before the end of the inspiratory act.

The morbid *physical condition represented by bronchial breathing* is either complete or considerable solidification of lung with the larger bronchi is still patent (*vide* p. 30). Whenever the chest is auscultated over lung solidified, if there be not absence of respiratory sound, the sound is tubular. This significance renders the sign of diagnostic value in the diseases which involve solidification. The sign *per se* denotes simply this morbid physical condition; the particular disease which exists is ascertained by means of the associated signs and the symptoms.

Solidification of lung is incident to several different diseases. In lobar pneumonia it is due to a fibrinous exudation within the air vesicles. In phthisis it is caused by an exudation in the same situation. In chronic or fibroid pneumonia the lung is solidified by an interstitial growth. The compression of lung from either pleuritic effusion, an accumulation of air in the pleural cavity, or the pressure of a tumor, causes solidification by condensation. Collapse of pulmonary lobules also solidifies by condensation. Coagulation of blood within the air vesicles (hemorrhagic infarctus) and neoplastic infiltration or growth are other causes of solidification. In these different affections, if the solidification be complete or considerable, this sign is

usually present; it is always present if there be not suppression of respiratory sound.

It is sometimes the case that either the inspiratory or the expiratory sound is wanting. The characters of the sign suffice for its recognition if either the inspiratory or the expiratory sound be alone present; the pitch and the quality are distinctive. Both sounds are often so intense that they are diffused more or less beyond the limits of the solidified portion of lung. The expiratory sound, being more intense than the inspiratory, is transmitted farther than the latter. This explains the conjunction sometimes of a vesicular inspiration with a tubular expiration; and a cavernous inspiration may be conjoined with a tubular expiration, showing the proximity of solidified lung in the former case to healthy lung, and in the latter case to a pulmonary cavity.

The sound may seem near the ear, or to come from a certain distance. The latter is appreciable in some cases of large pleuritic effusion; the tubular respiration is more or less distant, and it is sometimes diffused over the whole of the side which is filled with liquid.

Bronchovesicular Respiration.—This name was introduced by me, in 1856, to denote the combination, in varying proportions, of the characters of the bronchial or tubular, and of the normal vesicular respiration. The name expresses such a combination. It embraces modifications to which have been applied the terms, *rude, rough,* and *harsh respiration,* and

those included by German authors under the name *indeterminate* respiratory sounds.

The sign represents the different degrees of solidification of lung, between an amount so slight as to occasion only the smallest appreciable modification of the respiratory sound, and an amount so great as to approximate closely to the degree giving rise to bronchial or tubular respiration. In other words, all the gradations of respiratory modifications, *caused by incomplete or an inconsiderable solidification,* which fall short of bronchial or tubular respiration, are embraced under the name bronchovesicular. The gradations correspond to the amount of solidification, that is, they show the solidification to be either very slight, slight, moderate, or nearly sufficient to be considered as considerable or complete. The sign is therefore important as evidence (1) of the existence of solidification; and (2) of the degree of solidification.

Analyzing this sign, the most distinctive feature is the *combination of the vesicular and the tubular quality* in the respiratory sound. These two qualities may be combined in variable proportions. The pitch of the sound is raised in proportion as the tubular predominates over the vesicular quality. The expiratory sound is more or less prolonged, tubular in quality, and the pitch is raised. The prolongation of this sound, its tubular quality, and the highness of pitch, are proportionate to the predominance of the tubular over the vesicular quality in the inspiratory sound.

If the solidification of lung be slight, the characters

of the normal vesicular respiration predominate; that is, the inspiratory sound has but a small proportion of the tubular quality, and is but little raised in pitch, the expiratory sound being not much prolonged, its tubularity not marked, the pitch not high. If, on the other hand, the solidification of lung be almost enough to give a bronchial respiration, the inspiratory sound has only a little vesicular quality, the tubular quality predominating, the pitch proportionately raised; and the expiratory sound is prolonged, tubular, and high, nearly to the same extent as in the bronchial respiration. The less the solidification, the more the characters of the normal vesicular predominate over those of the bronchial respiration, and, *per contra*, the greater the solidification, the more the characters of the bronchial predominate over those of the normal vesicular respiration. Daily auscultation in a case of lobar pneumonia during the stage of resolution affords an opportunity to study all the gradations of this sign. After resolution has made some progress the inspiratory sound is no longer purely tubular, but the ear appreciates a little admixture of the vesicular quality and the pitch is slightly lowered. As resolution goes on the vesicular quality increases, the pitch is correspondingly lowered, until, at length, no tubularity remains, and the pitch becomes normal. Meanwhile, as the vesicular quality increases in the inspiratory sound, the expiratory sound is less and less prolonged, high and tubular; until it becomes, as in health, short, low, and blowing.

The bronchovesicular respiration is an important diagnostic sign in all the affections which involve partial solidification of lung. In lobar pneumonia, as just stated, it denotes the progress made from day to day in resolution. It is found also in an earlier stage, before the solidification is sufficient to give rise to a purely bronchial respiration. It is a valuable sign in phthisis, affording evidence, not only of the fact of solidification, but of its degree and extent. The sign enters into the diagnosis of interstitial pneumonia, hemorrhagic infarctus, condensation of lung from the pressure of either liquid, air, or a tumor, and from collapse of pulmonary lobules. It may be stated with respect to this sign, that it is always present if the lung be partially solidified, provided there be not either suppression of respiratory sound, or such a degree of feebleness that the distinctive characters are undeterminable. As with the bronchial respiration, so with the bronchovesicular, either the inspiratory or the expiratory sound may be wanting. The characters of the sign are then to be determined as they are manifested in the sound which is present, namely, the combination of the vesicular and the tubular quality, with more or less elevation of pitch, if only an inspiratory sound may be heard; and the amount of prolongation, tubularity, and elevation of pitch, if there be only an expiratory sound.

In determining the presence of this morbid sign at the summit of the chest on the right side, it is to be borne in mind that the respiratory murmur on

this side has, in health, as compared with the respiratory murmur at the summit on the left side, more or less of the characters of the bronchovesicular respiration (*vide* Normal Bronchovesicular Respiration, p. 119).

Amphoric Respiration.—This sign grades imperceptibly into cavernous respiration (*vide* p. 34), from which many authors do not distinguish it. The term amphoric denotes a musical intonation which may be compared to the sound produced by blowing upon the open mouth of a decanter or phial. Whenever the respiratory sound has this intonation it denotes a large space containing air. Air in the pleural cavity, with perforation of lung, is the physical condition most frequently represented by this sign. It is a valuable diagnostic sign in cases of pneumothorax; but it is not always present in that affection, certain accessory conditions being requisite—namely, perforation above the level of liquid, and an unobstructed communication of the bronchial tubes, through the opening, with the pleural space containing air. While, therefore, its presence is significant of pneumothorax, its absence is by no means sufficient to exclude this affection. Not infrequently it is a sign of a phthisical cavity with walls which do not collapse with the act of respiration. The same contingencies affect its production here as in cases of pneumothorax. Whenever amphoric respiration is present, if pneumothorax be excluded by the absence of the other signs which are diagnostic of this affection, the sign is proof of the

existence of a pulmonary cavity, the walls of which are not flaccid. The sign then takes the place of the ordinary cavernous respiration which is to be described below.

The amphoric sound may accompany either inspiration or expiration, or both. Amphoric respiration may be artificially illustrated by connecting an India-rubber bag of considerable size (such as is contained within a football) with a flexible tube, and after dilating it with air, inflating it forcibly either by a pair of bellows or by the mouth, holding the bag close to the ear. The amphoric sound thus produced represents the amphoric respiration as a sign in pneumothorax. As the sign of a tuberculous cavity it may be illustrated by a similar experiment, using an India-rubber bag of the size of an egg or orange. I have localized a tuberculous cavity with rigid walls in the centre of a lobe by artificially inflating phthisical lungs after their removal from the body.

Cavernous Respiration.—The modifications which constitute the distinctive characters of this sign are produced by the entrance of air into a cavity with the act of inspiration, and its exit from the cavity with the act of expiration. This passage of air into and from a cavity can only take place where the walls of the cavity collapse more or less in expiration and expand in inspiration. Pulmonary cavities occur chiefly in cases of phthisis. They occur, but with comparative infrequency, as a result of circumscribed abscess and gangrene of lung.

A well-marked cavernous respiration has characters which are highly distinctive when this sign is contrasted, on the one hand, with either the bronchial or bronchovesicular respiration, and, on the other hand, with the normal vesicular murmur. These distinctive characters relate both to the inspiratory and expiratory sound. *The inspiratory sound* is neither vesicular nor tubular in quality, and the pitch is low as compared with the bronchial respiration. As regards quality, we may say of it, as of the expiratory sound in the normal vesicular respiration, it is simply a blowing sound. *The expiratory sound* has the same quality as the inspiratory, and it is lower in pitch. Its duration is variable. The intensity of both the inspiratory and the expiratory sound varies; intensity does not enter into the distinctive characters of this sign more than into those of the bronchial and the bronchovesicular respiration. With a practical knowledge of the foregoing characters distinctive of the cavernous respiration, there is no difficulty in discriminating this sign from the bronchial respiration. The sign is more likely to be confounded with the normal vesicular murmur, inasmuch as it differs from the latter only in the absence in the inspiratory sound of the vesicular quality. Against this error the student is to be cautioned. It is most likely to be made when the inspiratory sound is much weakened, and, consequently, the vesicular quality less distinctly appreciable.

A cavernous respiration is limited to a space more

or less circumscribed, the area corresponding to the site and the size of the cavity. Occurring, for the most part, in cases of phthisis, it is much oftener found at the summit than elsewhere over the chest. It is not constantly found where there is a cavity with flaccid walls. It may be temporarily suppressed by the presence of liquid within the cavity, and by obstruction of the orifices communicating with bronchial tubes. It may be wanting at one moment, and an act of expectoration may cause it to reappear. Hence absence of cavity cannot be predicated on the absence of the sign at a single examination. Moreover, if a cavity be not situated near the pulmonary superficies, and solidified lung intervene between it and the walls of the chest, the cavernous sign may be drowned in a loud bronchial respiration. For this reason, while the cavernous sign is positive evidence of a cavity, the absence of the sign is not proof that a cavity does not exist.

In some cases of perforation of lung with pneumothorax, the passage of air to and fro through the perforation may give rise to the cavernous respiration. But, as a rule, the resonating properties of such large air chambers are so productive of overtones that the more musical sounds called amphoric respiration are found.

The cavernous respiration may be reproduced by the inflation of lungs after their removal from the body, the binaural stethoscope being placed over a cavity. This is true, also, of the bronchial and the

bronchovesicular respiration. These signs may be thus illustrated not infrequently after death from phthisis in lungs in which are cavities together with portions completely or moderately solidified.

The distinctive characters of the cavernous respiration may also be illustrated by means of a small India-rubber balloon with openings at opposite ends. Inflating the balloon through a tube introduced into one opening produces a sound analogous to the cavernous inspiration, and the expulsion of the air by the elasticity of the balloon produces a sound analogous to the cavernous expiration. A Davidson syringe may be used to inflate the balloon. The sounds are heard by applying lightly to the balloon the binaural stethoscope. This illustration demonstrates the mechanism of the cavernous respiration.

Bronchocavernous Respiration.—In this sign, as the name denotes, the characters of the bronchial and the cavernous respiration are combined. These characters may be combined in different ways, as well as in variable proportions. If a cavity be situated in proximity to solidified lung, the quality and pitch of the inspiratory and the expiratory sound may show an admixture of the characters of the two signs, and to a practised ear the combination is distinctly recognizable. This is one of the forms of bronchocavernous respiration; the sounds are not sufficiently high and tubular for bronchial, nor sufficiently low and blowing for cavernous respiration. Another form consists of an inspiratory sound, the first part of

which is tubular, and the latter part cavernous. Examples of this form are not extremely infrequent (metamorphosing respiration). Still another form is a cavernous inspiratory, with a bronchial or tubular expiratory sound. In the latter form the bronchial expiration proceeds from solidified lung situated near the cavity, the intensity of the sound being sufficient to drown the cavernous expiration.

When, as often happens, a cavity is situated in close proximity to, or, it may be, surrounded by solidified lung, the cavernous and the bronchial respiration are, as it were, in juxtaposition, and such instances offer an excellent opportunity to study the points distinguishing these signs from each other; and, generally, at a short distance the normal vesicular murmur may be found, so that both morbid signs may be compared with the latter. Within a circumscribed area sometimes are exemplified the characters of the normal murmur, and of the two morbid signs just mentioned, together with those of the bronchovesicular respiration.

Vesiculocavernous Respiration.—It is sometimes evident that the vesicular and the cavernous quality are combined in the inspiratory sound. This occurs when a cavity is surrounded, not by solidified, but by healthy lung. Under these circumstances, over the site of the cavity the inspiratory sound may be as loud as, or louder than, that around the cavity, but the quality is not purely cavernous; some vesicular quality is appreciable. A vesiculocavernous respira-

tion, then, is a cavernous respiration *plus* some vesicular quality derived from the air vesicles which are proximate to the cavity.

Shortened Inspiration.—The inspiratory sound is somewhat shortened in bronchial respiration. This modification enters into the characters of that sign, the quality of the sound being tubular, and the pitch high. The shortening is due to the sound ending before the inspiratory act ends; the sound is said to be unfinished.

Shortening of the sound occurs, however, when it is not an element in the bronchial respiration. The shortening is then due to the sound not beginning with the inspiratory act; this is distinguished as deferred inspiratory sound. A deferred inspiratory sound not tubular in quality, but more or less vesicular, and not notably raised in pitch, is a sign of pulmonary or vesicular emphysema. It is a sign of value in connection with the diagnosis of that disease.

The student should note the distinctions just stated, which relate to pitch and quality. Suppose an inspiratory sound to be present without an expiratory sound; if the sound be shortened at the end of the inspiration, the pitch high, and the quality tubular, it is bronchial respiration, denoting complete or considerable solidification of lung; but if the shortening be at the beginning of inspiration, the pitch comparatively low, and vesicular quality be appreciable, the sign denotes emphysema. The differential points thus are the inspiratory sound either unfinished

or deferred, the pitch either high or low, and the quality either tubular or vesicular. Attention to these points is essential in order to avoid error in the interpretation of the sign.

Prolonged Expiration.—The length of the expiratory sound in health varies in different persons. The sound is sometimes considerably prolonged; it may be nearly as long as the sound of inspiration. There is no difficulty in recognizing this as a normal peculiarity, from the fact that the murmur has the pitch and quality of health.

An unusual length of the expiratory sound, within the range of health, is usually observed at the summit of the chest, and especially on the right side. It is important to bear in mind that at the summit of the chest on the right side, and sometimes also on the left side, a prolonged expiratory sound, more or less raised in pitch, and tubular in quality, *may be a normal peculiarity.* It follows that a prolonged and even a high and tubular expiration at the summit of the chest must not be reckoned as a morbid sign unless it be associated with other signs denoting disease. The laws of the disparity between the two sides of the chest at the summit are to be taken into account (*vide* p. 117). If the expiration be longer on the left than on the right side, it is abnormal; so, also, is a high-pitched tubular expiration heard on the left and not on the right side.

The *significance of an abnormally prolonged expiration depends on its pitch and quality.* If it be high

and tubular, it denotes solidification of lung. It is, in fact, bronchial respiration. As already stated, in bronchial or tubular respiration the inspiratory sound is sometimes wanting, and the presence of the sign is then to be determined by the characters, relating to pitch and quality, of the expiratory sound. The same statement holds true with respect to bronchovesicular respiration, when this approximates to the bronchial. At the summit of the chest, the characters of the inspiratory sound, and associated morbid signs, always enable the auscultator to determine whether a prolonged high and tubular expiration be, or be not, abnormal. A prolonged expiration, which is low in pitch and blowing in quality, that is, with the characters of health, aside from length, may belong to a cavernous expiration. This is to be determined by the characters of the inspiration and by other associated signs. Exclusive of cavernous respiration, an abnormally prolonged expiratory sound of low pitch and non-tubular denotes vesicular emphysema. It is associated then with a weakened and deferred inspiratory sound. A prolonged expiratory sound, in cases of emphysema, is invariably low and non-tubular. If it have not these characters, it is not a sign of emphysema, but belongs to bronchial or bronchovesicular respiration.

A prolonged expiration at the summit of the chest on the right side is sometimes incorrectly considered to be evidence of phthisis. It is to be recollected, in the first place, that prolongation of this sound

with a normal pitch and quality, is never evidence of solidification of lung either from phthisis or any other disease; and in the second place, even if the pitch be high, and the quality tubular, that it is not to be regarded as abnormal provided the inspiratory sound is unchanged, and other signs of disease are not present. At times in bronchitis, there is a prolonged expiratory sound which may be distinguished as a sonorous expiration, not amounting to a rale. This is likely to be mistaken for bronchovesicular breathing.

Interrupted Respiration.—To this sign have been applied other names, such as *jerking, wavy,* or *cog-wheel* breathing. The modification is either of the inspiration or of the expiration, or of both. The inspiratory, however, much more frequently than the expiratory sound is interrupted. The sound instead of being continuous, is broken into one, two, or more parts. If at the same time there be alterations in pitch and quality, the interruption is merely incidental to other signs—namely, the bronchial, bronchovesicular, or cavernous respiration. As a distinct sign it has but little diagnostic value.

Interrupted respiration is sometimes found in healthy persons. It is confined to the summit of the chest, and oftener on the left than the right side. Existing without any other signs, therefore, it is not evidence of disease. It is of value only in the diagnosis of phthisis. Associated with other signs,

when the latter are not marked, it is entitled to a certain amount of weight in the diagnosis.

Interrupted respiratory sounds, of course, occur when there is interruption in the respiratory movements. This happens in cases of pleurisy, pleurodynia, or intercostal neuralgia. Owing to the pain caused by the movements in respiration, the patient may breathe, not continuously, but with a series of jerking movements. Sometimes interrupted breathing is observed in persons who are excited or agitated when auscultation is practised. In all these instances interruption in the respiratory sounds is found over the whole chest, whereas, when it is an abnormal sign in cases of phthisis, it is limited to a localized area.

Summary.—Reviewing the foregoing signs, they may be distributed into three classes, as follows: (1) Signs, the distinctive characters of which relate either to the absence or to the intensity of sound. This class embraces (*a*) increased intensity of the vesicular murmur; (*b*) diminished intensity of the vesicular murmur; and (*c*) suppression of respiratory sound. (2) Signs, the distinctive characters of which relate especially to pitch and quality. In this class belong (*a*) bronchial or tubular respiration; (*b*) bronchovesicular respiration; (*c*) amphoric and cavernous respiration; (*d*) bronchocavernous respiration; and (*e*) vesiculocavernous respiration. (3) Signs, the distinctive characters of which relate especially to rhythm—namely, (*a*) shortened inspiration; (*b*) prolonged expiration; and (*c*) interrupted respiration.

THE VOCAL SIGNS OF DISEASE.

The vocal signs of disease, with the exception of metallic tinkling, which is a vocal as well as respiratory sign, may all be considered as *abnormal modifications of the normal vocal resonance and of the normal whisper.* The student must therefore be familiar with the distinctive characters of these two normal signs before entering upon the study of the abnormal modifications (*vide* pp. 121 and 127). We must bear in mind the facts which have been presented in relation to the normal vocal fremitus (*vide* p. 123). The rules given for auscultation of the voice are also to be observed (*vide* p. 110). Embracing the abnormal modifications of the voice, the whisper and fremitus, the following are the signs to be considered: Bronchophony; whispering bronchophony; egophony; increased vocal resonance; increased bronchial whisper; cavernous whisper; pectoriloquy; amphoric voice or echo; diminished and suppressed vocal resonance; diminished and suppressed vocal fremitus, and metallic tinkling.

BRONCHOPHONY.

Bronchophony has the same import as bronchial or tubular respiration. It occurs when the muffling action of normal alveoli (*vide* p. 30 ff.) is abolished. Therefore *its presence indicates, like bronchial breathing, that the lung is completely or largely consolidated.* Gen-

erally the two signs are associated, but either may be present without the other.

The characters which are distinctive of bronchophony, as compared with normal vocal resonance, are these: The vocal sound seems concentrated, in most cases near the ear, the articulation clear-cut, and the pitch is more or less raised. These characters are in contrast with the diffusion, distance, and lowness of pitch of the normal vocal resonance. The intensity of the sound is variable; it may be greater or less than the intensity of the normal resonance. A concentrated, high-pitched sound, however feeble, is not less a sign of complete or considerable solidification of lung. In other words, intensity is not essential.

Vocal fremitus is always to be discriminated from vocal resonance. The fremitus associated with bronchophony may, or may not, be greater than the fremitus of health. Vocal fremitus while usually increased, is not infrequently less than in health.

It is to be borne in mind that in some healthy persons bronchophony exists at the summit of the chest, especially on the right side, over the primary bronchus, and also because of the close proximity of the trachea (*vide* p. 119). Existing in this situation it may not be abnormal.

Representing complete or considerable solidification of lung, *this sign occurs in the different affections in which bronchial or tubular respiration has been seen to occur* (*vide* p. 139), namely, lobar pneumonia, phthisis, chronic or fibroid pneumonia, condensation

of lung from either pleuritic effusion, the accumulation of air in the pleural cavity or the pressure of a tumor, collapse of pulmonary lobules, coagulation of blood within the air vesicles, and sometimes in neoplasm of lung.

For the production of bronchophony, *a less degree of solidification is requisite than for the production of bronchial or tubular respiration.* Hence, bronchophony may be associated with a bronchovesicular, as well as with a purely bronchial, respiration. This is illustrated in the resolving stage of pneumonia. When resolution has progressed sufficiently for the bronchial to give place to the bronchovesicular respiration, well-marked bronchophony is often found to continue, ceasing at a later period in the resolving stage.

The apparent nearness to the ear of the vocal sound in bronchophony is wanting if a certain quantity of liquid intervene between the solidified lung and the walls of the chest at the situation auscultated. The voice under these conditions seems to be more or less distant. This difference is readily appreciated. With this apparent distance of the bronchophonic voice in some instances is associated the modification which is characteristic of another sign—namely, egophony.

WHISPERING BRONCHOPHONY.

The characters of this sign correspond to those of the expiratory sound in the bronchial or tubular

respiration (*vide* p. 127). The sound is more or less intensified, high in pitch, and tubular in quality. If the patient pronounce numerals in a forced whisper, the characters are generally more marked than in the expiratory sound in forced breathing. The significance of this sign is usually the same as that of the bronchial or tubular respiration, and of bronchophony with the loud voice.

In the diagnosis of enlarged bronchial glands in children D'Espine has recently drawn attention to the significance of this sign when present below the spine of the seventh cervical vertebra. Howell found that the bronchial whisper over the cervical vertebræ usually persisted to the second or third dorsal spines in infancy, that at six years it was inaudible at the second dorsal spine in 40 per cent., and at twelve years in 85 per cent. of normal children. He concluded that bronchial whisper at or below the third dorsal spine is valuable evidence of enlarged bronchial glands. (W. W. Howell, *Am. Jour. Dis. Child.*, 1915, xx, 90.)

EGOPHONY.

This sign is *a modification of bronchophony.* As regards concentration and pitch, it has the characters of bronchophony, the distinctive features being apparent distance from the ear, the tremulousness or a nasal, bleating tone. From the latter the name is derived, the term signifying the cry of the goat. The characters which distinguish the sign from broncho-

phony are readily enough appreciated, and it represents a physical condition added to solidification of lung. This physical condition is the presence of liquid effusion. The sign is rarely present in cases of large effusion. It occurs usually when the chest is about half-filled with liquid, and the lung at the level of the liquid is sufficiently condensed to give rise to bronchophony. This condition, under these circumstances, involves relaxation of lung above the portion condensed by pressure. The sign also sometimes occurs in cases of pleuropneumonia, the solidification in these cases being due to pneumonic exudation. As a sign of liquid effusion it possesses diagnostic value, although, owing to the fact that the existence of effusion is easily determined by other signs, it may be said to be superfluous. When the person examined speaks with the teeth approximated, bronchophony has somewhat the character of egophony.

INCREASED VOCAL RESONANCE AND FREMITUS.

The distinctive character of this sign is an increase of the intensity of the resonance without notable change in other respects. The resonance is still distant, diffused, and comparatively low in pitch; in other words, the characters distinctive of bronchophony are wanting.

Increased vocal resonance occurs when the lung is solidified, the solidification not sufficient in degree

to produce bronchophony. *Lung slightly or moderately solidified gives rise to an increase of the intensity of the resonance of the voice;* if the solidification becomes considerable or complete, bronchophony takes the place of the simple increase of intensity. Thus, at an early period in pneumonia, increased vocal resonance precedes bronchophony; and in the stage of resolution the reverse of this takes place—namely, increased vocal resonance follows bronchophony, the latter ceasing when resolution has progressed to a certain extent.

Contrary to what would perhaps be anticipated in the instances just cited, the intensity of the sound, when bronchophony is present, may be sometimes diminished below that of health, that is, in the first stage of pneumonia the increased intensity may cease when bronchophony occurs, and return when bronchophony disappears.

Increase of the vocal resonance occurs in connection with pulmonary cavities. Over a cavity of considerable size, situated near the superficies of the lung, the vocal resonance is sometimes extremely intense, without any bronchophonic characters. If bronchophony be present, it denotes considerable solidification either around the cavity, or between it and the walls of the chest. From the presence or the absence of bronchophonic characters combined with greatly increased intensity of resonance, the auscultator can judge whether the cavity be, or be not, in proximity to considerable solidification of lung.

Besides the cavernous stage of phthisis, the sign is of diagnostic importance in the different affections which involve moderate or slight solidification of lung—namely, pneumonia early in the disease and in the stage of resolution, phthisis, over the compressed lung in pleurisy with moderate effusion, collapse of pulmonary lobules, hemorrhagic infarcts, and neoplasms of lung. Into the diagnosis of all these affections, both bronchophony and increased vocal resonance enter; the former when solidification is considerable or complete, and the latter when it is slight or moderate.

Increased vocal resonance is especially valuable in the diagnosis of early or incipient phthisis. An abnormal resonance, however slight, at the summit of the chest on one side, is an important sign in that affection. In determining an abnormal resonance on the right side, either of the summit or elsewhere, allowance must always be made for the normally greater resonance on this side.

Increased vocal resonance has the same import as bronchovesicular respiration. These two signs, however, are not always in the same proportion, that is, the characters of the latter may be marked, out of proportion to the amount of the increase of the vocal resonance, and *vice versa.*

Increased vocal fremitus generally accompanies increased vocal resonance, and it denotes solidification of lung. Fremitus, however, and resonance are not always in equal proportion, that is, either may

11

be increased more than the other. An increased fremitus is sometimes of value in the diagnosis of phthisis. The greater fremitus on the right side of the chest is always to be borne in mind, and due allowance is to be made for this normal disparity.

INCREASED BRONCHIAL WHISPER.

The significance of this sign is the same as that of increased vocal resonance and the bronchovesicular respiration; it represents the same physical condition as the two latter signs—namely, solidification of lung, greater or less, but below the degree requisite to give rise to bronchophony and bronchial respiration. Its diagnostic application is therefore involved in the same pulmonary affections.

The *characters of the sign* are those which belong to the expiratory sound in the bronchovesicular respiration. They consist, therefore, of increase of intensity, a quality more or less tubular, and the pitch raised, these modifications varying in degree, between the slightest appreciable change, and a close approximation to the bronchophonic whisper. The modifications in degree correspond to the degree of solidification. To appreciate the characters of this sign it must be studied in comparison with those of the normal whisper in different portions of the chest. The most important of the diagnostic applications of the sign is in cases of phthisis in its

early stage. In this application the points of normal disparity between the two sides of the chest at the summit are to be borne in mind, and due allowance made for them (*vide* p. 117).

A greater intensity of the bronchial whisper at the right than at the left summit is not evidence of disease; but greater intensity at the left summit is always abnormal. As a rule the pitch of the normal whisper at the left is higher than that at the right summit. In doubtful cases, with greater intensity of whisper at the right apex, elevation of pitch is indicative of disease. For the significance of whisper over the upper dorsal vertebræ, D'Espine's sign, see page 158.

Cavernous Whisper.—The characters distinctive of the cavernous whisper are those of the expiratory sound in the cavernous respiration—namely, lowness of pitch, and the quality blowing. The intensity is variable. It is limited to a circumscribed space corresponding to the situation and size of the cavity. Not infrequently the characters of the sign are brought into contrast with those of whispering bronchophony or increased bronchial whisper; these latter signs existing in close proximity, and representing solidification of lung in the immediate neighborhood of the cavity.

Pectoriloquy.—In pectoriloquy, not merely the voice, but the speech, is transmitted through the chest; the auscultator recognizes words uttered by the patient.

The student, however, must not expect to be able to carry on a conversation with the patient by means

of the stethoscope. Often single words only can be recognized. To make sure that these are transmitted through the chest, care must be taken to exclude their direct transmission from the patient's mouth, and the auscultator should not know beforehand the words which are to be spoken. If these rules be not observed, the auscultator may err in supposing that the words are transmitted through the chest. When auscultation is practised with one ear, the other should be closed.

The speech with either the loud or the whispered voice may be transmitted, the latter, distinguished as *whispering pectoriloquy, being much more frequent* than the former; moreover, in determining whispering pectoriloquy, there is less liability to error in mistaking the perception of words coming directly from the mouth for transmission through the chest. In the production of this sign much depends on the distinctness with which words are articulated by the patient. Normal pectoriloquy at the anterior superior portion of the chest is sometimes observed.

Pectoriloquy belongs among the cavernous signs; but it is by no means exclusively the sign of a cavity; the speech may also be transmitted by solidified lung. It is easy to determine in any case whether the sign denotes a cavity or solidified lung. If, with transmitted speech, the voice has the characters of bronchophony, the sign represents solidification of lung; if, on the other hand, the characters of bronchophony be wanting, the sign represents a cavity.

Amphoric Voice or Echo.—This sign is identical in character with amphoric respiration, with which it is usually associated (*vide* p. 144). The production of both depends upon the resonator action of a large air cavity by which both fundamental and particularly overtones are intensified and prolonged. The amphoric intonation may accompany the loud voice and the whisper; generally it is more appreciable or marked with the latter. *Its significance is the same as that of amphoric respiration.* As a rule it represents the conditions in pneumothorax—namely, a large space filled with air and perforation of lung. In this affection it is associated with other signs which suffice for a prompt and positive diagnosis. It is not invariably found in pneumothorax, and it may be present in a case at one time and wanting another time; its production being dependent on the perforation being freely open, and on the bronchial tubes leading to the perforation being unobstructed. When not associated with other signs which are diagnostic of pneumothorax, it denotes a phthisical cavity of considerable size. It is not infrequently a sign of a phthisical cavity with rigid walls and communicating freely with bronchial tubes.

The amphoric sound sometimes is observed to follow the oral voice; hence the name amphoric echo.

Diminished and Suppressed Vocal Resonance.—Diminution or suppression of the normal vocal resonance *occurs especially when the pleural cavity contains either liquid or air.* Whenever the lungs are not in contact

with the walls of the chest, the vocal resonance, as a rule, is either notably lessened or wanting. The sign is, therefore, of value in diagnosis in cases of pleurisy with effusion, empyema, hydrothorax, and pneumothorax. When the pleural cavity is partially filled with liquid, there is diminution or suppression of the resonance from the level of the liquid downward, and generally, just above the level of the liquid, the resonance is increased, owing to condensation of the lung. The sign is well illustrated by the contrast in such cases above and below the level of the liquid. As a rule moderate changes of the level of the liquid with changes in position of the body may be as well demonstrated by means of vocal resonance as by percussion. Exceptionally, however, this rule is not available.

The vocal resonance may be diminished or suppressed when the lung is completely solidified in the second stage of pneumonia, if the consolidation involves the bronchi, resulting in their obstruction (massive consolidation); in pulmonary edema and over the site of an intrathoracic tumor, abscess or cyst.

If the vocal resonance be normal, that is, neither increased nor diminished, we are warranted in excluding all the affections which have been named; the exceptional instances are so rare that, practically, they may be disregarded.

In emphysema and in chronic pleurisy with marked thickening of the parietal or visceral pleura, or of both, due to organized fibrin and connective tissue, we

find marked instances of diminished and suppresed vocal resonance.

The normal disparity between the two sides of the chest is to be borne in mind with reference to diminished or suppressed, as well as to increased, vocal resonance; otherwise the relative feebleness of the resonance on the left side in health might be considered to be morbid. The normally greater resonance on the right side renders it easier to determine a morbid diminution on this than on the left side.

If the stethoscope be firmly pressed upon the lower part of the chest wall, especially in front, above the lower border of the lung, there may be a great suppression or even total absence of vocal resonance. The vibration of the chest wall, particularly in the lower part, is easily interfered with by a too firm pressure of the stethoscope bell upon the chest.

Diminished and Suppressed Vocal Fremitus.—This tactile sensation, which is appreciable in auscultation, as a rule, is increased, and diminished or suppressed, under the same physical conditions which occasion corresponding modifications of the vocal resonance. Usually the abnormal modifications of resonance and fremitus go together, but either may be out of proportion to the other. The signs relating to fremitus thus corroborate those relating to resonance.

Diminished or suppressed fremitus is valuable in the diagnosis of pleurisy with effusion, empyema, hydrothorax, pneumothorax, emphysema, and chronic thickened pleura. It is, however, to be noted that in

exceptional instances the fremitus persists over the site of liquid within the chest.

With regard to vocal fremitus, as to vocal resonance, it is essential to remember the normal disparity between the two sides of the chest, the greater relative fremitus being normally on the right side.

Metallic Tinkling.—This sign has the same characters when it accompanies either the loud or whispered voice, as when it is heard with respiration, and, of course, it has the same significance (*vide* p. 186). It may be more marked with acts of speaking than with the respiratory acts.

SIGNS OBTAINED BY ACTS OF COUGHING OR TUSSIVE SIGNS.

Acts of coughing may be made subservient to auscultation of respiratory sounds in two ways: (1) By the removal of temporary obstruction from the accumulation of mucus within bronchial tubes. If the respiratory murmur be diminished or suppressed over a portion of the whole of one side of the chest, sometimes an act of coughing effects dislodgement of a mass of mucus from either a primary bronchus or one of its subdivisions, and the normal murmur is at once restored. The dependence of the morbid sign upon a temporary obstruction is thus demonstrated. (2) By an act of coughing more air is expelled than by an ordinary expiration, and in the following inspiration the vesicles have a wider range of expan-

sion, giving rise to a proportionately loud inspiratory sound; hence the characters of this sound are pronounced and can be better studied. For these two objects it is often advisable to request the patient to cough with a certain degree of force.

This procedure of having the patient cough at the end of an expiratory act and immediately breathe in freely is of particular advantage in eliciting the elusive fine crepitations at the apices of the upper or lower lobes in suspected or early pulmonary tuberculosis. Care must be taken that the patient does not swallow after the cough, as the *deglutition sounds are readily mistaken for adventitious sounds arising in the lungs.*

Acts of coughing, moreover, give rise to auscultatory signs which have their analogues in signs obtained by respiration and the voice. When the conditions are present which are represented by bronchial respiration, bronchophony and the bronchophonic whisper, sounds are obtained which correspond to these in their characters. The cough is then said to be bronchial. With the stethoscope applied over an empty cavity of some size, situated near the surface of the lung, the ear receives with acts of coughing a concussion or shock which is sometimes so forcible as to be painful. This corresponds to an intense vocal resonance. Limited to a circumscribed space, it is a highly significant cavernous sign. It may be present when the cavernous respiration is wanting. A low-pitched, blowing sound corresponds to the expiratory sound in the cavernous

respiration and the cavernous whisper. An amphoric intonation may be heard with acts of coughing which corresponds to amphoric respiration and amphoric voice. This sign is sometimes more marked with cough than with the breathing and voice. Cavernous gurgling may also be obtained more distinctly with cough than with respiration. Finally, metallic tinkling not infrequently accompanies acts of coughing.

ADVENTITIOUS RESPIRATORY SOUNDS, OR RALES.

Adventitious respiratory sounds, or rales, are distinguished from the morbid signs already considered, by the fact that they have no analogues in health; in other words, they *are not normal sounds abnormally modified, but wholly new sounds.* They are usually classified as: (*a*) Dry rales, which are produced by the presence of thick tenacious exudations within the bronchial tubes or by muscular spasm of the tubes; and (*b*) moist rales, due to the presence of liquid. These primary groups are then subdivided according to the different anatomical situations in which they are produced, as follows: (1) Laryngeal and tracheal rales; (2) bronchial rales; (3) vesicular rales; (4) cavernous rales; (5) pleural rales; (6) indeterminate rales.

Laryngeal and Tracheal Rales.—The rales produced within the larynx and trachea may be either moist or dry. *The moist or bubbling sounds are produced when mucus or other liquid accumulates* in these sections

of the air tubes. This occurs frequently in the moribund state, and the sounds are then known as the "death rattles." When not incident to this state, they denote either insensibility to the presence of liquid, as in coma, or inability to effect the removal of the liquid by acts of expectoration. The sounds are heard at a distance. They exemplify, on a large scale, moist or bubbling auscultatory sounds which are produced within the bronchial tubes. *Dry sounds produced within the larynx or trachea are caused by spasm of the glottis, and by diminution of the calibre,* either at or below the glottis, from edema, exudation, the presence of a foreign body, or the pressure of a tumor. The dry sounds are distinguished as whistling, wheezing, crowing, whooping, etc. They are heard at a distance, and they also exemplify auscultatory sounds representing analogous conditions in the bronchial tubes. Characteristic sounds, produced at the glottis by spasm, enter into the diagnosis of certain affections—namely, laryngismus stridulus, pertussis, croup, and aneurism involving excitation of the recurrent laryngeal nerve. Other sounds are due to paralysis of the laryngeal muscles. Again, dry sounds produced by stenosis of the trachea from the pressure of an aneurismal or other tumor, cicatrization of ulcers, and morbid growths, are of diagnostic importance. Although audible without auscultation, these different sounds, with reference to the precise situation at which they are produced, may sometimes be studied with advantage by means of the stethoscope.

They are embraced under the name stridor. The respiration, voice, and cough, when accompanied by these sounds, are said to be stridulous.

MOIST BRONCHIAL RALES.

The moist bronchial rales are *bubbling sounds produced in different branches of the bronchial tree.* They are sounds of which the "tracheal rattles" are an exaggerated type. They may be imitated by blowing into liquids through tubes differing in size. They may also be produced in the lungs of the sheep or the calf, after removal from the body, by injecting into the bronchi glycerin or some other liquid, and imitating the respiratory acts by means of a pair of bellows, auscultation being practised with the stethoscope applied upon the surface of the lung, or with several thicknesses of cloth intervening. The bubbles seem to be *large or small according to the size of the bronchial tubes in which they produced.* Apparent differences in the size of the bubbles are distinguished by the names coarse and fine. In the primary and secondary bronchial branches the moist sounds are relatively quite coarse; they are less so in tubes of the third or fourth dimensions; in smaller tubes they become fine, and in those of minute size they become extremely fine.

Extremely fine bubbling sounds constitute what has been known as the *subcrepitant rale,* so-called because it approaches in character to the crepitant rale, pro-

duced within the air vesicles and bronchioles. We may thus judge of the size of the bronchial tubes in which the rales are produced by their comparative coarseness or fineness. Frequently, however, coarse and fine rales are intermingled, and generally, those which are either coarse or fine are not uniform, but appear to be of unequal size. In all the varieties of the moist bronchial rales the bubbling character of the sounds is sufficiently distinctive for their recognition. The differentiation of the so-called subcrepitant from the crepitant rale alone involves some nice points of distinction.

Coarse bubbling rales sometimes occur in acute bronchitis affecting the larger bronchial tubes. Their occurrence is exceptional, because, in general, the mucus within the tubes does not accumulate sufficiently and is too consistent for the production of bubbling sounds. These rales occur in cases in which the mucus is unusually thin, and either more abundant than usual, or an accumulation takes place in consequence of inability to expectorate freely. These conditions are wanting in the majority of the cases of ordinary acute bronchitis. A mucopurulent liquid in cases of chronic bronchitis is better suited for the production of bubbling sounds than simple mucus. Moreover, coarse rales are heard oftener in children than in adults, because the former do not voluntarily expectorate as freely as the latter. Serous transudation (bronchorrhea) into tubes of large size may give rise to coarse bubbling rales, and also the presence of

blood in some cases of profuse hemorrhage. In bronchitis and bronchorrhea the rales are heard on both sides of the chest. The bubbling rales, whether coarse or fine, are heard either with the act of inspiration or of expiration, or with both acts.

Fine bubbling sounds and the so-called subcrepitant rale occur in various pathological connections. The characters of the latter are to be borne in mind with reference to the discrimination from the crepitant rale. The most distinctive character is the moist sound or bubbling; this is sufficiently appreciable. Other characters are their occurrence frequently, in expiration as well as in inspiration, and the inequality of the fine bubbling sounds.

The so-called subcrepitant rale, existing over the chest on both sides, is diagnostic of bronchitis affecting the smaller bronchial tubes (capillary bronchitis), when taken in connection with other signs, and the symptoms. The rales exist on both sides, because this, as well as bronchitis affecting the larger tubes, is a bilateral affection. The sign is of great practical value in the diagnosis of that variety of bronchitis. The rale also occurs on both sides, and is more or less diffused in pulmonary edema. The connection with the latter affection is shown by the associated physical signs, together with the symptoms. In so-called capillary bronchitis the bubbling is due to the presence of thin mucus, and in pulmonary edema to serous transudation within the small bronchial ramifications.

Fine bubbling or the so-called subcrepitant rale has other pathological connections, as follows:

1. It occurs in lobar pneumonia during the stage of resolution. Here it is due to the presence of mucus from a bronchitis limited to the affected lobe or lobes, and, in a measure, to liquefied pneumonic exudation. It is considered as denoting commencing and progressing resolution in pneumonia. Sometimes it is intermingled with rales which are more or less coarse.

2. In circumscribed pneumonia, hemorrhagic infarctus, and pulmonary apoplexy, the fine or subcrepitant rale, often associated with those which are more or less coarse, denotes the presence of mucus or of blood within the bronchial tubes. The rales are localized in space, or in spaces, corresponding to the situation and extent of the affection.

3. During and shortly after a hemoptysis, fine rales limited to a particular situation are sometimes heard, proceeding from blood in the small bronchial tubes, and indicating the situation of the hemorrhage.

4. A purulent liquid admits of bubbling much more readily than mucus; hence, in cases of chronic bronchitis with an expectoration of pus, fine and coarse bronchial rales are more frequent than in acute bronchitis. Pus also, may be present within bronchial tubes of small size, not as a product of bronchitis, but from the evacuation of an abscess of either the pulmonary parenchyma, of the liver, or some other adjacent part, and from perforation of lung in some cases of empyema.

5. In the different stages of phthisis moist bronchial rales are usually present. The liquid in the tubes, if the disease be advanced, is derived, in part, from associated bronchitis, and, in part, from liquefied tuberculous exudation. The bubbling sounds may be more or less coarse or fine, and both are often intermingled. Early in the disease, before softening of the exudation has taken place, fine bubbling, or the subcrepitant rale, limited to the summit of the chest, is an important diagnostic sign. This fine subcrepitant rale in early pulmonary tuberculosis is heard also, and not infrequently, at the tip of the lower lobes behind, in the interscapular regions. It belongs among the accessory physical signs on which the diagnosis may depend. Here the liquid is derived from a coexisting circumscribed bronchitis.

In cases of fibroid phthisis, or cirrhosis of lung, moist rales, coarse and fine, are generally more or less abundant and diffused over the whole, or the greater part, of the chest on the affected side.

In the foregoing account of the moist bronchial rales the subcrepitant rale is not reckoned as a sign distinct from fine bubbling sounds. Inasmuch as the mechanism and the significance are the same, and it is not easy to draw a line of demarcation between the two, the distinction is unimportant. It is sufficient to bear in mind that very fine bubbling sounds are called subcrepitant, because they are somewhat analogous to the crepitant rale. The points which distinguish the latter are, however, well marked, as

will appear when the characters of that sign are considered. The term subcrepitant gives rise to confusion, and there is no advantage in retaining it as the name of a distinct sign. Very fine bubbling expresses more correctly the characters of the sign. The moist rales are often called mucous rales. This name is obviously inappropriate, since not only are the sounds produced by other liquids than mucus, but other liquids are best suited for their production, especially in the large and medium-sized tubes.

The several varieties of the moist bronchial rales may be produced by the injection of a liquid in varying quantity into the bronchi of the lungs removed from the body of an animal of sufficient size, *e. g.*, of the sheep or calf, and imitating respiration by means of bellows.

The moist bronchial rales, whether coarse or fine, vary in pitch accordingly as the lung surrounding the tubes in which they are produced is or is not solidified. *If the lung be solidified, the pitch is high; if there be no solidification, the pitch is comparatively low.* Thus the pitch of the rales is high in the second stage of pneumonia and in phthisis with considerable solidification, whereas the pitch is low in bronchitis and pulmonary edema. If, therefore, the respiratory sound be suppressed, it is easy to determine by the pitch of these rales whether the lung be solidified or not, and to judge measurably of the degree of solidification. Attention to the pitch in connection with these rales is sometimes of value in diagnosis.

DRY BRONCHIAL RALES.

All adventitious sounds which are not moist, produced within the air tubes below the trachea, are embraced under the name *dry bronchial rales*. The sounds are many and varied in character. They are often musical notes. Frequently they are suggestive of certain familiar sounds, such as the chirping of birds, the cry of a young animal, snoring in sleep, cooing of pigeons, humming of the mosquito, the note of the violoncello, etc. They are often heard at a distance, and characterized as wheezing sounds. An interrupted or clicking sound is not uncommon.

All these varieties are practically unimportant, and it would be a needless refinement to consider particular varieties as distinct signs. The only distinction which it is desirable to make is into the sibilant and sonorous rales. This distinction is based on difference in pitch; *sibilant rales are high, and sonorous rales are low in pitch.* As a rule the sibilant rales are produced in the small and the sonorous rales in the larger sized bronchial tubes. The sounds may accompany either inspiration or expiration, or both. The sibilant and sonorous rales are often intermingled. There may be sibilant rales with inspiration, and sonorous rales with expiration, within the same situation. Moreover, these rales are found often to vary from minute to minute, being at one instant sibilant, and at another sonorous. Students are likely to confound sonorous rales with bronchial breathing, and sometimes with friction sounds.

The physical condition represented by the dry rales is diminished calibre of the air tubes at certain points, and especially in consequence of spasm of the bronchial muscular fibers. The latter constitutes the essential pathological condition in a paroxysm of asthma; and in this affection the dry rales are always marked. Their diagnostic importance relates chiefly to asthma. Both sibilant and sonorous rales are present and diffused over the entire chest. Wheezing sounds with expiration are heard by the patient and by others at a distance. A single paroxysm of asthma affords an opportunity for the student to observe all the varieties and fluctuations of these rales. Taken in connection with other signs and symptoms, the rales are pathognomonic of asthma.

More or less spasm of the bronchial muscular fibers occurs in certain cases of bronchitis, without being sufficiently great and extensive to give rise to a paroxysm of asthma or even any embarrassment of respiration. Under these circumstances the rales are less marked and diffused. An asthmatic element may be said to enter, more or less, into these cases. Narrowing of bronchial tubes by tenacious mucus which gives rise to no bubbling sounds, and, perhaps, unequal swelling of the mucous membrane may also occasion sibilant and sonorous râles in bronchitis.

Dry rales at the summit of the chest are not infrequent in cases of phthisis due to spasm, the presence of mucus, or to swelling of the mucous membrane. They are sometimes quite annoying to phthisical patients.

Clicking sounds are suggestive of the sudden separation of tenacious mucus from the walls of the bronchial tubes. These are sufficiently common in bronchitis and in phthisis.

VESICULAR OR CREPITANT RALE.

This is the only vesicular rale. It is usually considered to be produced within the air vesicles, but probably the terminal bronchial tubes or bronchioles participate in its production.

It is to be distinguished from very fine bubbling sounds, or the so-called subcrepitant rale. The points of distinction are as follows: The sounds are crackling, not bubbling in character. They may be defined to be very fine crackling sounds. This point of difference is very distinctive. There are, however, other differential points. The crackling sounds are equal, whereas, fine bubbling sounds are unequal, that is, they give the impression of bubbles of unequal size. The crepitating sounds are heard at the end of the inspiratory act, and especially at the end of a forced inspiration, the subcrepitant rale, on the other hand, being heard often with or near the beginning of inspiration, and, perhaps, ceasing before the end of the inspiratory act. Another distinctive feature is the abrupt development of the crepitant rale; there is a shower of crackles, as it were, at the end of a forced inspiration. Finally, the rale is never heard in expiration. The apparent exceptions to this state-

ment are instances in which the crepitant and the subcrepitant rale are associated. This is not very infrequent, and, with a practical knowledge of the characters of each, it is by no means difficult to appreciate the combination of the two signs. In fact, the combination affords an excellent opportunity to illustrate the distinctive characters of each; the fine bubbling at, or near the beginning of inspiration, followed by the fine crackling at the end of this act and the former perhaps reproduced in the act of expiration.

There are various modes in which the crepitant rale may be imitated; for example, rubbing together a lock of hair near the ear, throwing fine salt upon live coal or into a heated vessel, igniting a train of gunpowder, and alternately pressing and separating the thumb and finger moistened with a solution of gum arabic and held near the ear. A perfect representation is afforded by squeezing a piece of an artificial preparation known as the India rubber sponge, and observing the sound produced by the separation of the walls of the interstices when the piece expands from its elasticity. This preparation exemplifies the true mechanism of the sign as described, first, by the late Dr. Carr, of Canandaigua, N. Y., in an article published in the *American Journal of Medical Sciences,* in October, 1842.[1] Expansion of the lungs of the sheep or calf, after removal from the body, the stetho-

[1] *Vide* article by the author in the New York Monthly Med. Jour. for February, 1869.

scope being applied to the lung surface, gives, in certain situations, a well-marked crepitant rale.

The crepitant rale is a common sign in pneumonia. It very rarely occurs in any other pathological connection. Of all respiratory signs, this is most entitled to be called pathognomonic. It belongs especially to the first stage of acute pneumonia. It is not invariably present, but it occurs in the majority of cases of acute pneumonia. In the second stage, or the stage of solidification, the rale generally disappears. It not infrequently is reproduced in the stage of resolution, and it is then called the returning crepitant rale. In the latter stage it is often found in combination with the subcrepitant rale. The practical value of this sign relates chiefly to the diagnosis of pneumonia.

It is stated that the crepitant rale is sometimes found in cases of pulmonary edema, and during or directly after an attack of hemoptysis. If it ever occur in these cases, the instances must be extremely rare. The statement is perhaps based on the occurrence of the subcrepitant, this being confounded with the crepitant rale. It occurs transiently under the following circumstances: A patient who has been confined for some time in bed, lying on the back, and much enfeebled with any disease, if suddenly raised to a sitting posture and auscultated, a crepitant rale is often found on the posterior aspect of the chest at the end of a forced inspiration. The rale disappears after a few forced inspirations. It is

heard, not on one side only, but on both sides. The explanation is that during the recumbent posture, continued for some time and the patient breathing feebly, enough of the air vesicles and bronchioles become agglutinated by means of a little sticky transudation to give rise to crackling sounds in a few forced inspirations. It may be of use to mention that if the stethoscope be applied to the anterior surface of a chest much covered with hair, the movements of the pectoral extremity of the instrument in the act of inspiration may produce a sound identical with the crepitant rale. This can be eliminated by applying oil or vaseline liberally over the hairy surface.

A crepitant rale at the summit of the chest, within a circumscribed space, is one of the accessory signs of phthisis. It denotes a circumscribed pneumonia which clinical experience shows to be generally secondary to phthisis; hence the diagnostic significance of the sign.

CAVERNOUS OR GURGLING RALE.

A pulmonary cavity of considerable size, containing a certain quantity of liquid, and communicating freely with bronchial tubes, furnishes a rale which is characteristic. The character of the sound is expressed as fully as possible by the term gurgling. The sound is produced by large bubbling and the agitation of the liquid within the cavity. It may be compared to the sound produced by the boiling

of a liquid in a flask or large test-tube. The sound is sometimes high pitched and amphoric, but generally it is low in pitch. It is heard with more or less intensity within a circumscribed space, almost invariably at or near the summit of the chest; but if intense, the sound is diffused, and it may be sometimes heard at a distance. Its diagnostic importance relates to the advanced stage of phthisis. The rale is heard chiefly or exclusively in the act of inspiration. It may be produced by the act of coughing sometimes with greater intensity than by respiration.

PLEURAL RALES—FRICTION SOUNDS—METALLIC TINKLING—SPLASHING.

The signs embraced under the name pleural rales are: (1) Sounds produced by the rubbing together of the pleural surfaces, and hence called friction sounds; (2) metallic tinkling; (3) splashing or succussion sounds.

Friction Sounds.—Movements of the pleural surfaces upon each other take place in inspiration and expiration; but in health these movements occasion no sound. Sounds are produced when the surfaces are covered with a recent fibrinous exudation which prevents the normal continuous, unobstructed movements.

The sounds are generally interrupted, that is, two, three, or more sounds occur during the act of inspiration or expiration, or during both acts. The intensity of the

sounds varies much in different cases. A slight grazing sound only may be heard, or, on the other hand, the sounds may be so loud as to be heard by the patient, and by others at a distance. The character of the sounds is variable. The slight rubbing or grazing character may be imitated by placing over the ear the palmar surface of one hand, and moving over its dorsal surface slowly the pulpy portion of a finger of the other hand. In some instances, however, the rough character of the sounds is expressed by such terms as rasping, grating, and creaking. In these instances the sounds denote density of the morbid product which roughens the pleural surfaces. In connection with very rough sounds, vibration of the walls of the chest, or fremitus, is sometimes perceived by palpation.

Aside from the character of the sounds as just stated, they are distinguished by their apparent nearness to the ear; they seem sometimes to be produced upon the surface of the chest. They are sometimes intensified by firm pressure of the stethoscope upon the chest. After a little practical knowledge of these sounds they can hardly be confounded with any other rales.

Pleuritic friction sounds generally denote pleurisy. In cases of pleurisy with effusion, slight rubbing or grazing is sometimes heard before much liquid accumulates within the pleuritic cavity. The physical conditions, however, after the effusion has been removed, are much more favorable for the production of friction sounds, and they are often now rough

in character. They may be transient, or they may continue for a considerable period, their duration depending on the arrest of the movements of the pleural surfaces by means of either agglutination with fibrin, or adhesion from the growth of areolar tissue.

Pleuritic friction sounds occur not infrequently in cases of pneumonia, denoting, in this connection, coexisting pleurisy.

Slight rubbing or grazing at the summit of the chest is one of the accessory signs of phthisis. It denotes a circumscribed, dry pleurisy, which, as clinical experience shows, is generally secondary to phthisis, and hence the diagnostic significance of the sign.

In the foregoing instances in which friction sounds are stated to occur, their significance relates to pleurisy. In some rare instances the sounds are produced by miliary tubercles, or neoplastic nodules projecting beyond the plane of the visceral pleural surface, without pleuritic inflammation.

Metallic Tinkling.—This is a vocal as well as a respiratory sign. It is also produced by acts of coughing, and sometimes by the act of deglutition. The name expresses the distinctive character of the sign. It consists in a series of tinkling sounds of a high-pitched, silvery, or metallic tone. The number of sounds varies from a single sound to two, three, or more sounds, during an act of either inspiration or expiration. This sign may be imitated in various ways by means of an India rubber bag of considerable size. Forcing a liquid into the bag with Davidson's

syringe, tapping the bag with the finger, or shaking it will produce tinkling sounds. The best mode of artificial representation of the sign is to connect the bag with a flexible tube, the latter containing a few drops of liquid, and blowing into the tube so as to produce bubbles at the communication of the tube with the bag. In this latter experiment it is not necessary that the bag contain any liquid. It occurs irregularly, that is, it is not present in every act of breathing, but is heard at variable intervals. It may sometimes be produced by forced, when it is not heard in tranquil, breathing. It can only be confounded with tingling sounds sometimes produced within the stomach. The latter, however, are easily discriminated by their situation, and the absence of associated signs denoting the affections of the chest in which the sign occurs.

Metallic tinkling is the sign of pneumothorax with perforation of lung. In the great majority of the cases in which it is found it is diagnostic of this affection. It is, however, always associated with other physical signs corroborative of the diagnosis.

It is a rare sign, in cases of phthisis, of a large pulmonary cavity, the conditions for its production being analogous to those in pneumohydrothorax, namely, a space of considerable size containing air, the space communicating with bronchial tubes.

Splashing, or Succussion Sounds.—This sign is produced by succussion, which is reckoned as one of the different modes of physical exploration. Sounds

thus produced are not infrequently heard at some distance. Generally, however, succussion is practised while the ear is applied to the chest, so that properly enough the sign may be embraced among the auscultatory signs, although not produced by respiration.

Splashing is pathognomonic of either hydropneumothorax or pyopneumothorax. It is especially valuable as a sign of these affections because it is almost invariably available. The instances are extremely few in which the sign is wanting when air and liquid are contained in the pleural cavity. It is obtained by jerking the body of the patient with a quick, somewhat forcible movement, the ear being in contact with the chest.

The sound is like that produced when a bottle partially filled with liquid is shaken. The sound is often high-pitched and amphoric in quality. The only liability to error is in confounding with this sign splashing produced within the stomach. Attention to other signs will always protect against this error.

Indeterminate Rales.—Under this head may be embraced some sounds sufficiently recognizable, but indeterminate as regards the rationale of their production and the physical conditions which they represent. They may be designated crumpling and crackling sounds. The former are probably due to pleuritic rubbing, and the latter to the separation of some slightly adherent air vesicles or bronchioles. Their diagnostic value relates only to the early stage

of phthisis. In conjunction with other signs, any indeterminate rale, if limited to the summit of the chest, and especially to one side, has some weight in the diagnosis. Crumpling and crackling sounds, however, are *not uncommon in healthy persons* at the end of forced inspiration. The fact of their presence at both summits, and the absence of other morbid signs, are the grounds for not considering them as evidence of disease. They are found in health, especially if the binaural stethoscope be employed. Their *diagnostic significance,* thus, depends on limitation to the summit of the chest on one side, and association with other signs pointing to incipient phthisis.

CHAPTER VII.

THE PHYSICAL DIAGNOSIS OF DISEASES OF THE RESPIRATORY ORGANS.

Affections of the larynx and trachea—Bronchitis seated in large bronchial tubes—Bronchitis seated in small bronchial tubes, or capillary bronchitis—Collapse of pulmonary lobules—Lobular pneumonia—Asthma—Pulmonary or vesicular emphysema—Pleurisy, acute and chronic—Empyema—Hydrothorax—Pneumothorax—Hydropneumothorax—Pyopneumothorax—Acute lobar pneumonia—Circumscribed pneumonia—Embolic pneumonia—Hemorrhagic infarctus—Pulmonary apoplexy—Pulmonary gangrene—Pulmonary edema—Neoplasms of lung—Tumor within the chest—Acute miliary tuberculosis—Pulmonary phthisis—Fibroid phthisis—Interstitial pneumonia, or cirrhosis of lung—Diaphragmatic hernia.

In the preceding chapters we have considered the abnormal physical conditions incident to morbid changes in the respiratory tract. The effect of these pathological physical conditions upon the physical signs has been studied; and the distinctive characters of each physical sign have received particular attention, in order that the abnormal signs may be recognized.

The object of this chapter is to group together the physical conditions in the different diseases of the respiratory system, with the representative signs on which rests the physical diagnosis of each of the

diseases. The scope of this manual is limited to the physical diagnosis of these affections; but the fact is *not to be lost sight of that in practical medicine physical signs are not to be disassociated from symptoms and pathological laws.* An exclusive reliance on physical signs would lead to errors in diagnosis, although, doubtless, errors more important and more frequent necessarily occur when the practitioner ignores percussion and auscultation. The signs furnished by percussion and auscultation only have been thus far considered, but in grouping these in this chapter signs obtained by other methods of physical exploration will be embraced in so far as they enter into the diagnosis of the different diseases of the respiratory system. These different diseases will be taken up separately with the exception of those seated in the larynx and trachea. With reference to physical signs, the laryngeal and tracheal affections may be considered collectively.

AFFECTIONS OF THE LARYNX AND TRACHEA.

The physical signs referable to the chest in diseases of the larynx and trachea denote more or less obstruction to the free passage of air through these sections of the air tubes. The obstruction in the different diseases involves different pathological conditions. *Spasm of the glottis* is one of these conditions, constituting the affections known as laryngismus stridulus and spasmodic croup, occurring also as a

pathological element in laryngitis, and sometimes in connection with aneurism, or a tumor of some kind involving the recurrent laryngeal nerve. Another pathological condition is the opposite of this, namely, *paralysis* of the muscles of the glottis, the vocal cords remaining flaccid and approximating during inspiration. Other pathological conditions are *edema* of the glottis, swelling of the membrane at the glottis in laryngitis, together with, in the adult, submucous infiltration, diphtheritic exudation, cicatrization of ulcers, morbid growths, and the presence of foreign bodies.

In the affections involving the foregoing pathological conditions percussion and auscultation are of use: (1) By enabling the physician to exclude all diseases within the chest. The absence of signs showing the existence of pulmonary diseases renders it certain that the symptoms denoting embarrassment of respiration are referable to the larynx or trachea. (2) By means of auscultation the amount of obstruction may be determined more accurately than by the subjective symptoms. The amount of obstruction is represented by a proportionate weakening of the vesicular murmur. This is more reliable as regards determining a dangerous amount of obstruction than the sense of the want of air or the suffering of the patient. The degree of diminution of the vesicular murmur is determinable with more accuracy the better the auscultator is acquainted with the normal intensity, that is, the intensity prior to the occurrence of obstruc-

tion. With this knowledge the weakening of the murmur is a correct criterion of the amount of obstruction. In all the pathological conditions named the respiratory murmur is more or less diminished in intensity on both sides of the chest; there are no signs obtained by percussion, nor do vocal resonance or fremitus offer anything distinctive.

In cases of considerable or great obstruction during inspiration inspection furnishes marked signs. The expansion of the chest on both sides is restricted, the lower part of the chest is contracted in the act of inspiration, and in this act the soft parts above the clavicles are depressed. The contrast between these abnormal movements and the normal thoracic movements of the patient is striking and distinctive.

An important application of auscultation is the *localization of a foreign body which has been inhaled.* If the vesicular murmur on both sides be more or less weakened, the foreign body must be situated in either the larynx or the trachea. If, on the other hand, the vesicular murmur be weakened or suppressed on one side, and increased on the other side, the body is lodged in a primary bronchus. The importance of this application of auscultation before opening the trachea to remove a foreign body is sufficiently obvious. The situation of a foreign body may be changed from one bronchus to the other by an act of coughing, even after an operation has been commenced; this is, of course, at once determinable by auscultation.

By the application of *x*-ray examination, especially

when combined with stereoscopic study of the plates, invaluable information is to be obtained as to the location of foreign bodies within the air passages. When available it should be used to supplement auscultation and percussion.

BRONCHITIS SEATED IN LARGE BRONCHIAL TUBES.

In bronchitis, either acute or chronic, as it is ordinarily presented in practice, the inflammation is seated in the large bronchial tubes, in many cases probably not extending beyond the primary and secondary bronchi. The physical conditions are more or less swelling of the mucous membrane (this, however, not being sufficient to occasion any notable obstruction to the free passage of air) and the presence, in different cases, in greater or less quantity, of mucus, mucopurulent matter, pure pus, and serum.

The physical *diagnosis involves negative rather than positive points;* in other words, the diseases from which bronchitis is to be differentiated are excluded by the absence of their diagnostic signs. These diseases are pneumonia, pleurisy, and phthisis. Each of these is characterized by the presence of signs, the absence of which warrants its exclusion. In bronchitis there is no disparity between the two sides of the chest in size, symmetry, or mobility; in the resonance obtained by percussion, nor in vocal resonance, the bronchial whisper, and fremitus. The swelling of the bronchial

mucous membrane may cause some diminution of the intensity of the vesicular murmur, but as the affection is bilateral and the bronchial tubes on each side are affected equally, both in degree and extent, no appreciable disparity in this respect between the two sides is caused by this physical condition. Weakening or suppression of the murmur over an area greater or less may be caused by bronchial obstruction from a plug of mucus. This obstruction is sometimes removed by an act of expectoration, after which the murmur is found to have returned, or to have regained its normal intensity.

The foregoing points, taken in connection with the history and symptoms, suffice for the diagnosis. Signs due directly to the disease represent diminished calibre of the tubes at certain points from swelling of the membrane, adhesive mucus, and spasm of bronchial muscular fibers. These signs are the dry bronchial rales. They are rarely prominent, and are oftener absent than present, if the bronchitis be unaccompanied by asthma; hence, they are of little value in the diagnosis. Other signs are the bubbling sounds or the moist bronchial rales. In acute bronchitis these are oftener absent than present. They occur when liquid morbid products within the tubes are unusually abundant, or when the removal of these is with difficulty effected by expectoration in consequence of muscular debility or other causes. These rales are abundant and loud in proportion as the liquid within the tubes is either mucopurulent, purulent, or serous in char-

acter. They are more or less coarse in proportion to the size of the tubes in which the bubbling takes place.

The diagnostic points, negative and positive, which have been stated, are alike applicable to acute and chronic bronchitis, it being, of course, understood that the affection is primary, that is, not secondary to some other pulmonary disease.

If the bronchitis be unaccompanied by solidification of lung, the moist rales which may be present are low in pitch. The pitch is raised and the sounds sharper and more crackling if there be solidified lung surrounding or adjacent to the tubes in which the moist rales are produced.

BRONCHITIS SEATED IN SMALL BRONCHIAL TUBES — CAPILLARY BRONCHITIS — COLLAPSE OF PULMONARY LOBULES—LOBULAR PNEUMONIA.

Inflammation extending into the small tubes (capillary bronchitis) occasions the same physical conditions which are incident to bronchitis affecting tubes of large size, namely, swelling of the membrane, and the presence of liquid morbid products. The exudates are not as easily removed by expectoration as when they are within large tubes, and therefore they are constantly present in greater or less quantity. These conditions in small tubes involve *obstruction to the passage of air* to and from the air vesicles; hence the vast difference as regards the symptoms, the suffering

and the danger. The affection is *bilateral,* a fact greatly enhancing the gravity of the affection. *An incidental physical condition is solidification,* generally in disseminated portions of lung, the latter varying in number and size. These portions of solidified lung denote either collapse of pulmonary lobules or lobular pneumonia, or both in conjunction. To this incidental affection German writers apply the name "catarrhal pneumonia." Of course any discussion of pathological questions suggested by these names would be here out of place. With reference to diagnosis it is to be borne in mind that the solidified portions of lung in cases of bronchitis seated in small tubes are especially situated in the lower lobes. *Another incidental physical condition is temporary dilatation of the air cells, or vesicular emphysema,* seated in the upper lobes. Both of these incidental conditions are bilateral, like the bronchitis with which they are connected. Collapse of pulmonary lobules, or lobular pneumonia, or both, and emphysema occur in only a certain proportion of the cases of bronchitis seated in small tubes. The signs, therefore, admit of a division into those which relate (1) to the bronchitis, and (2) to these incidental affections. With reference to the diagnosis, the fact is to be borne in mind that bronchitis seated in small tubes occurs chiefly in children and the aged.

Inspection even in severe cases reveals only moderate cyanosis and increase of respiration, in contrast to the dyspnea and cyanosis of pneumonia or asthma.

The physical diagnosis of bronchitis seated in

small tubes rests on negative points, together with a positive sign which is uniformly present. This sign is the *fine, moist bronchial or the so-called subcrepitant rale* present on both sides and diffused over the chest. The bubbling sounds are to be distinguished from the fine, dry crackling sounds or the crepitant rale, to the characters of which the former in some measure approximate.

The bronchitis gives rise to *no dulness on percussion, nor to any notable change in vocal resonance or fremitus.* The respiratory murmur, if not obscured by rales, is weakened on both sides. Irrespective of being drowned by rales, it may be suppressed by the amount of bronchial obstruction. These are the negative points in the diagnosis. In *pulmonary edema* fine, moist bronchial rales are present on both sides, but in this affection there is notable dulness on percussion, and the affection occurs in certain pathological connections —namely, with mitral stenosis, and disease of the kidneys. *Acute tuberculosis* may present the moist bronchial rales with the negative points which, in connection with symptoms, characterize bronchitis seated in the small tubes. The differentiation is to be based on differences pertaining to the history and duration, together with the age of the patient.

The coexistence of *the incidental affections,* namely, collapse of pulmonary lobules, or lobular pneumonia, and vicarious emphysema, occasions additional signs. Respiration is quickened, expiration being frequently cut short by the pain of an accompanying pleurisy,

so that the patient is seen to flinch with each breath. The ali nasi often dilate with each inspiration, and cyanosis is common. If the solidified portions of lung be considerable in either number or size, there will be dulness on percussion in circumscribed situations on the posterior aspect of the chest. This will be found on both sides, but perhaps more marked on one side. Bronchovesicular or the bronchial respiration may be present, together with the vocal signs of solidification, namely, either increased vocal resonance, or bronchophony and increased vocal fremitus. The moist rales produced within solidified portions of lung are high in pitch, whereas, if solidification do not exist, these rales are comparatively low in pitch. The existence of solidification at any point may be determined by the pitch of the rales, as well as by the foregoing respiratory and vocal signs.

When there are emphysematous lobules on the anterior aspect of the chest in the upper and middle regions, on both sides, the resonance on percussion is vesiculotympanitic, the respiratory murmur weakened or suppressed, and the rhythm altered—in short, the combination of signs which will be stated under the head of emphysema.

In the cases in which the bronchitis occasions great obstruction in the small tubes, and, still more, if collapse of lobules, or lobular pneumonia and vicarious emphysema occur, important signs are obtained by inspection. The anterior portion of the chest remains expanded, and retraction of the lower part of the chest takes place in the acts of inspiration.

ASTHMA.

The pathologicophysical condition in *a paroxysm of asthma, is obstruction in the small bronchial tubes, attributable to spasm* of the bronchial muscular fibers. With this condition is associated a *temporary vesicular emphysema* which exists often as a persistent affection in persons who are subject to asthma. If the emphysematous condition already exists, it is increased during the paroxysm of asthma. *Bronchitis generally coexists,* either as a transient or a chronic affection. In an asthmatic paroxysm, therefore, there are present the signs which are proper to asthma, together with those of emphysema, and the associated bronchitis may also occasion additional signs.

On inspection the tremendous inspiratory efforts of the patient are pitiful; the accessory muscles of inspiration are all in action; and yet, in contrast to the dyspnea of tracheal or glottis obstruction, the act of inspiration is very quickly accomplished, and little drawing-in of the intercostal spaces is visible. Closer observation reveals that *expiration is slow and incomplete,* so that in spite of the extreme inspiratory efforts the actual amount of air drawn in with each breath is much decreased and the patient is cyanosed. As a result of these superimposed inspirations, with incomplete expiration, the thorax is overinflated and assumes the form to be described under Emphysema.

The physical diagnosis of asthma, like that of bronchitis seated in small tubes, is based on nega-

tive points taken in connection with a sign which is invariably present, namely, *dry bronchial rales.* These rales are more or less intense, and they are diffused over the entire chest. They are generally heard at a distance. The sibilant and sonorous varieties are mingled, and they are constantly changing as regards the character of the sounds.

The *negative points are the same as in capillary bronchitis,* namely, absence of dulness on percussion, vocal resonance and fremitus also being unaltered. Asthma and bronchitis seated in small tubes agree in the fact that obstruction is the important physical condition. A highly important differential point relates to the *frequency of the respirations* in cases exhibiting an equal degree of dyspnea and cyanosis; the respirations are much increased in frequency in capillary bronchitis and not in asthma. Pathologically they differ essentially in the fact that the obstruction is due in the latter affection to bronchial inflammation, and in the former to spasm. The two affections differ in the signs representing these different conditions—fine, moist bronchial rales existing in one, and loud, diffused, dry bronchial rales existing in the other.

Taking the difference, as regards the positive physical signs, in connection with the history and symptoms, the differentiation of the two affections may be made without difficulty.

The signs which relate to the associated emphysematous conditions are distinct from those occasioned

by the asthma itself. They will be considered later. Coexisting bronchitis may give rise to moist bronchial rales more or less coarse. These are, however, often wanting, and they are rarely marked during paroxysms of asthma. When present in this pathological connection they are low in pitch, denoting the absence of solidification of lung.

PULMONARY OR VESICULAR EMPHYSEMA.

This affection, as a rule, is often more marked in the upper lobes. When it is lobar, in contradistinction from the emphysema existing in comparatively a few disseminated or isolated portions of lung, *increase in volume* of the affected lobes is an important physical condition standing in relation to certain signs. *Diminished range of expansion* with acts of inspiration is another physical condition; the affected lobes are in a permanent state of expansion approximating to that at the end of the inspiratory act. It follows from these conditions that the amount of air is in excess of the normal proportion to the solids and liquids in the affected lobes. Both lungs are affected, that is, the affection is *bilateral.* In the great majority of cases chronic bronchitis coexists, and patients affected with emphysema are often, but by no means invariably, subject to paroxysms of asthma. Not infrequently an asthmatic element, with or without pronounced paroxysms of asthma, exists much of the time in connection with emphysema. The emphysematous

condition, as a rule, with few exceptions, is greater in the upper lobe of the left, than of the right lung.

A condition which is generally included under the name *senile emphysema* differs materially from the ordinary form of this affection. This condition is that also known as senile atrophy of the lungs. The volume of the lungs is not increased in this variety of emphysema; the proportion of air over the solids is, however, in excess, owing to the diminution of the latter from atrophy.

Inspection is of great value in *emphysema of the "large lung" type.* The thorax is seen to have permanently taken on the form assumed by a normal thorax in full inspiration. The ribs are abnormally horizontal; the anterior posterior diameter is unusually great, often equaling the width of the chest; the infracostal angle equals, or is usually greater than, a right angle; the normal curvature of the thoracic vertebræ is increased. The normal cardiac apex beat is not seen; while as a result of a flattened diaphragm and the elevation of the sternum, pulsation near the ensiform cartilage is unusually prominent. The external jugular veins are abnormally full because the normal negative intrathoracic pressure is decreased. Cyanosis is usually present, and occasionally of most extreme grades. The movements of the chest in inspiration are characteristic. In tranquil breathing there is but little movement of the upper and anterior regions, but in forced breathing the sternum and ribs move together as if they were one solid piece. The lower

portion of the chest and the epigastrium are retracted in inspiration, or the retraction may be only apparent; the costal angle is diminished, the ribs and cartilages connected with the sternum being sometimes on a line; the soft parts above the clavicle and sternum are often notably depressed with inspiration.

The diagnostic evidence obtained by percussion is quite distinctive of lobar emphysema. The resonance over the upper and middle regions of the chest on both sides is *vesiculotympanitic,* that is, the intensity of the resonance is abnormally increased, the quality is a combination of the vesicular and tympanitic, and the pitch is more or less raised. Owing to the fact that the emphysema is greater on the left than on the right side, the vesiculotympanitic resonance is more marked on the left side. The difference in intensity between the two sides may lead to the error of regarding the resonance on the right side as dulness. The error is avoided by attention to the pitch, and the quality of the resonance. If dulness existed on the right side, the pitch of the sound should be higher on that side; on the other hand, if the difference in intensity be due to the greater amount of emphysema on the left side, the pitch is higher on that side, and the quality vesiculotympanitic. The attention of the student is particularly called to the foregoing points of distinction. Assuming that a vesiculotympanitic resonance exists anteriorly on both sides, and that it is marked on the left as contrasted with the right side, how is the existence of this sign

on the right side to be determined? The answer is, the resonance over the upper is to be compared with that over the lower lobe of the right lung. Percussing first over the upper lobe of the right lung, and second over the lower lobe of this lung, that is, posteriorly, below the scapula, or in the infra-axillary region, the vesiculotympanitic resonance over the upper lobe is rendered manifest. In a series of patients affected with emphysema the uniformity of the results of percussion is very striking; anteriorly, over the left side, the resonance is vesiculotympanitic as compared with the resonance on the right side, and the resonance is shown to be visiculotympanitic on the right side anteriorly, as compared with the resonance posteriorly below the scapula.

Beside these distinctive qualitative changes in the note, percussion also reveals an increased area of pulmonary resonance. The borders of the lungs extend lower into the costophrenic sinus, and the anterior margins often completely obliterate the area of cardiac flatness.

As regards the abnormal modifications of the respiratory murmur in emphysema, there is (1) either *weakened respiratory murmur* without notable change in pitch or quality, or suppression of the murmur. Diminished intensity of the murmur exists over the upper lobes on both sides, as compared with the murmur over the lower lobes; and in most cases the greater diminution or the suppression is on the left rather than on the right side. Exceptions to the latter state-

ment may be caused by obstruction of the bronchial tubes on the right, and not on the left side, by an accumulation of mucus, and, in rare instances, by the fact that the emphysema is greater on the right side. Occasionally there is almost suppression below, with preserved respiration above, of the emphysematous type, and this so continuous as not to be explained by obstruction of tubes. (2) Modifications in rhythm are not infrequent. These consist in a shortened (deferred) inspiratory, and a *prolonged expiratory sound.* In some instances an inspiratory sound is wanting, and an expiratory sound is alone heard. The prolonged expiratory sound in emphysema is always low in pitch and non-tubular in quality, in these respects differing from the prolonged expiration which denotes solidification of lung, the latter being high in pitch and tubular in quality.

The foregoing signs obtained by percussion and auscultation are those which are, in a positive sense, diagnostic of emphysema. Associated with these are *certain important negative points,* as follows: vocal resonance, vocal fremitus, and whisper are not notably altered. These negative points suffice to exclude other affections than emphysema.

In the variety of emphysema distinguished as senile, or senile atrophy of the lungs, in which there is coalescence of air vesicles from destruction of the cell walls without increased volume of the affected lobes, the diagnosis is to be based on the vesiculo-typanitic resonance on percussion, weakened respi-

ratory murmur, with, perhaps, the alterations in rhythm, sinking of the soft parts above the clavicles, and the negative points, exclusive of deformity of the chest, which have been described.

Emphysema can hardly be confounded with any other affection than phthisis. The differentiation between these two affections is sufficiently easy if the diagnostic points, positive and negative, of the former, be appreciated. Phthisis occurring in a patient affected with emphysema makes a somewhat difficult problem in diagnosis; but, by strict attention to the associated history and symptoms, together with thorough examination of the sputum, errors will usually be avoided. Association of emphysema and pulmonary tuberculosis is not as uncommon as was formerly thought.

Owing to the frequency with which an asthmatic element enters into the clinical history of emphysema, the dry bronchial (sibilant and sonorous) rales are often present, even when paroxysms of asthma do not occur.

PLEURISY, ACUTE AND CHRONIC—EMPYEMA—HYDROTHORAX.

In the first stage of acute pleurisy—that is, prior to the effusion of liquid—the physical conditions are the presence of more or less recently exuded, soft fibrin upon the pleural surfaces, which are still in contact, and restrained movements of respiration

on the affected side in consequence of the pain which they occasion. In the *second stage serous liquid accumulates* within the pleural cavity, the quantity varying in different cases, sometimes, although rarely, filling the chest on the affected side. In proportion to the quantity of liquid, the space over which the pleural surfaces are in contact is restricted, the movements of these surfaces over each other are limited, and the lung is condensed. In the *third stage the liquid decreases,* the space over which the pleural surfaces are in contact increases, and the compressed lung is more or less expanded. The fibrin upon the pleural surfaces becomes more dense and adherent. The surfaces may become agglutinated by the intervening fibrin. Finally, in convalescence, permanent adhesions may result from the production or growth of areolar tissue.

In subacute and chronic pleurisy there is the same series of physical conditions, the points of difference being, as a rule, a less amount of exudation, and a greater amount of effused liquid. The quantity of liquid in chronic pleurisy is often sufficient to compress the lung into a small solid mass situated at the upper and posterior part of the chest and to dilate the affected side. The heart is often removed from its normal situation. If the pleurisy be on the left side, the heart may be pushed laterally beyond the right margin of the sternum; if the pleurisy be on the right side, the heart is pushed laterally to the left of its normal situation.

In empyema the accumulation of pus is apt to be still greater than that of serous effusion in simple chronic pleurisy, causing, of course, greater dilatation of the chest, and more displacement of the heart.

In these varieties of pleurisy the affection, with rare exceptions, is unilateral.

In *hydrothorax* the conditions differ, (1) as regards the absence of the exudation of fibrin; (2) the affection is usually bilateral, the effusion of liquid taking place in both pleural cavities; and, (3) although the quantity of liquid may be considerably greater on one side, and this is almost invariably the right side, the accumulation very rarely, if ever, is sufficient to cause much dilatation of the chest on that side, with complete condensation of the lung, and notable displacement of the heart.

The signs in acute fibrinous pleurisy are relative feebleness of the respiratory murmur on the affected side, from the restrained respiratory movements on that side, and a rubbing friction sound. The friction sound cannot be heard if only the diaphragmatic or mediastinal pleura is inflamed. The former sign is not distinctive of pleurisy, being present when the respiratory movements on one side are restrained by pain in intercostal neuralgia and pleurodynia. A friction sound is not always obtained. In the absence of this sound the physical diagnosis of acute pleurisy cannot be made with positiveness prior to the effusion of liquid.

When in doubt as to the site of origin of rales which

may be friction sounds or pulmonary crepitations, if the patient cough, the character of pulmonary rales is usually altered, and they may even disappear, while pleuritic friction sounds are unaffected. Also pressure of the stethoscope or hand may intensify the friction rub but does not alter the pulmonary crepitation. The friction sound is usually, but not invariably, heard only in inspiration.

Assuming that the general and local symptoms point to an acute inflammatory affection, the differential diagnosis relates to pleurisy and pneumonia. A friction sound is usually present in the latter because the adjacent pleura is almost invariably inflamed. The common sign of pneumonia, the crepitant rale, being wanting, the differentiation, in this stage, must rest on diagnostic points pertaining to changes in resonance and breath sounds. The crepitant rale may occur at the inception of pleurisy, without coexisting pneumonia, the mechanism of production being the same as in pneumonia.

In the second stage of acute pleurisy the diagnostic signs are those which denote the presence of *liquid within the pleural cavity.* These signs are simple and distinctive. The affected side is larger, and the intercostal depressions less distinct than normally; it moves less freely with respiration. There is either dulness or flatness on percussion at the base of the chest, extending upward a distance proportionate to the quantity of liquid. If the trunk be in a vertical position—that is, the patient sitting or

standing—the line of demarcation between the dulness or flatness and pulmonary resonance is curved. Posteriorly, the line of dulness or flatness is found to be a curve, starting about 2 inches from the posterior median line, and reaching its highest point at the posterior axillary line, the curve then descending in the axilla, to reach the liver or cardiac dulness in front, according to the side and the amount of the effusion (Ellis's, or Garland's line). In patients who have been confined to bed, the highest point of the line of dulness is frequently in a line drawn vertically through the middle of the scapula.

Having ascertained the line forming the upper boundary of dulness or flatness on the anterior aspect of the chest (the patient sitting or standing), if the position be changed to recumbency on the back, and the pulmonary resonance be found then to extend more or less below this line, this fact is demonstrative proof of the presence of liquid. The amount of shifting of this line of dulness may be only 1 or 2 inches in normal or rather flat chests, while in deep barrel-shaped chests 3 or 4 inches of movement may be found.

Where there is free pleuritic exudate on one side, there is found with considerable uniformity a triangular area of dulness on the opposite or unaffected side. The base of this area is made by the line of the base of the lung, and extends 2 or 3 inches from the posterior median line; the vertical side is somewhat longer usually and is as high in the midline as the

upper level of the fluid on the affected side. This is known as *the paravertebral triangle of dulness.* Proof in this way is obtained in a large majority of cases, the exceptional cases being those in which the pleural surfaces are united, either by agglutination or permanent adhesions, above the level of the liquid. An additional means of determining the level of the fluid, especially at the right base posteriorly where the presence of the liver may cause confusion on percussion, is by tapping one coin held firmly against the upper chest in front with another coin, when the ear below the level of the fluid will detect a much better transmission of the sound thus produced than when the ear is above the level of the fluid. Flatness over fluid is usually more intense and the sense of resistance to the pleximeter finger greater than over consolidatd lung.

The resonance on percussion over the lung above the level of the liquid is generally vesiculotympanitic (*Skodaic resonance*)—the intensity increased, the pitch raised, the vesicular and the tympanitic quality combined. Sometimes there is so little vesicular quality in this vesiculotympanitic resonance that it may seem to be purely tympanitic, and is suggestive of pneumothorax. Associated signs will always prevent this error of observation.

As a rule vocal resonance and fremitus are either notably lessened or suppressed over the portion of the chest situated below the level of the liquid. There are occasional exceptions to this rule.

The respiratory sound below the level of the liquid is suppressed. If any be heard, it is transmitted either from the lung above the liquid, or laterally, from the lung on the other side of the chest. Above the liquid the respiratory sound, as a rule, is weakened. If the amount of liquid be sufficient to produce much condensation of lung, the respiratory sound is bronchovesicular. Sometimes, owing to the pleural surfaces above being adherent, a strip of lung at the level of the liquid is sufficiently condensed by compression to give a bronchial respiration. Under these circumstances there will be either bronchophony or the modification of that sign known as egophony. If the lung be not sufficiently compressed for the production of these signs of solidification, the vocal resonance is simply more or less increased. The fremitus is usually increased above the liquid. Over the unaffected side the respiratory murmur is increased in intensity—compensatory respiration.

The foregoing signs are present when the pleural cavity is partially filled; a quarter, a half, or two-thirds of the thoracic space being occupied by liquid. The signs present when the cavity is completely filled will be presently stated in connection with chronic pleurisy.

The signs which have been stated show not only the presence of liquid but its quantity. By means of these signs are readily ascertained the progressive increase or decrease in the quantity of liquid, and its disappearance. After the liquid has disappeared

often notable dulness on percussion remains for some time, showing the presence of fibrin not yet absorbed. During the decrease of the liquid, and after its disappearance, a friction murmur is often perceived. This murmur is now apt to be rough—a rasping, grating, or creaking sound. It may be loud enough to be heard by the patient and by others at a distance from the chest. It continues sometimes for a considerable period.

The physical diagnosis in cases of chronic pleurisy, when the liquid occupies a portion only of the thoracic space, rests, of course, on precisely the same signs as in cases of acute pleurisy. Concident pleural thickening may, however, limit the respiratory movement of the affected side much more than in the case of acute pleural effusion, while occasionally that side is distinctly contracted. If, however, the chest on the affected side be filled and dilated, certain of the signs which have been stated are wanting, and others are added. The affected side is everywhere flat on percussion. Flatness on percussion over the whole of one side, the affection being chronic, denotes, as a rule, with rare exceptions, either chronic simple pleurisy or empyema. Respiratory sound is wanting except at the summit over or near the compressed lung, where it is bronchial. Some cases offer an important exception to this rule, namely, the bronchial respiration is diffused over the greater part, or even the whole, of the affected side. The student should bear in mind this fact, otherwise the diffusion of the

bronchial respiration may lead to the suspicion that the flatness on percussion denotes solidification of lung and not the presence of liquid. Other signs, however, should always correct this error. Vocal resonance and fremitus are, with some exceptions, either suppressed or notably diminished over the whole of the affected side. Generally, even when the chest is not dilated, the intercostal depressions are lessened or abolished. If the walls of the chest be thinly covered with integument, the two sides present a marked contrast in this respect. This is seen especially at the middle and lower regions of the chest anteriorly and laterally. It is especially marked at the end of the inspiratory act. If the affected side be dilated, this is apparent on inspection, and may be determined accurately by measurement. The respiratory movements on the affected side are diminished or annulled, and they are increased on the healthy side, the two sides affording a marked contrast in this regard. If the pleurisy be on the left side, the impulses of the heart are not infrequently felt on the right of the sternum. If the impulses cannot be felt, auscultation shows the maximum of the intensity of the heart sounds to be more or less removed to the right. If the pleurisy be on the right side, the impulses or sounds of the heart denote more or less displacement laterally to the left, and this altered position may be still further determined by percussion of the cardiac border adjacent to healthy lung. The intensity of the respiratory murmur on

the unaffected side is notably increased, as the patient is forced to do practically all his breathing with one lung.

In cases of *empyema* the same signs are present as in simple pleural effusion. Neglected cases come under observation with large accumulations of pus which give signs like those found in large non-purulent effusions. The character of the liquid does not alter appreciably any of the signs which have been stated. Dilatation of the affected side of the chest is more apt to occur, and to be more marked than in simple pleurisy. The differential diagnosis between these two varieties of pleurisy is to be made with positiveness by the introduction of the needle of an exploratory syringe having good suction force, previously cleaned and carbolized, and obtaining enough of the liquid to ascertain its character.

When the left pleural cavity is filled with pus, the movements of the heart sometimes give to the affected side of the chest an impulse perceived by the eye and touch; hence the term, pulsating empyema. This condition has been observed even when the empyema has been confined to the right pleural cavity. After a spontaneous perforation of the chest, followed by a circumscribed purulent collection beneath the integument, communicating with the pus within the pleural cavity, the tumor thus formed sometimes has a strong pulsation which is synchronous with the ventricular systole, and may give rise to the suspicion of aneurism.

Empyema of less advanced grade is much more

frequently met. Here the signs are usually similar to those encountered in small serous effusions—dulness, decreased (usually faint bronchial) breath sounds, voice and fremitus. On the other hand, there is a much greater tendency to the formation of adhesions and to encapsulation, so that movable dulness and the S-shaped line of Ellis are less frequent, while atypical signs suggesting consolidation are occasionally met.

In cases of *hydrothorax* the signs denote partial filling of the chest on both sides. The affection is usually bilateral. Generally the quantity of liquid in the two sides is not equal, and there is often a notable disparity in this respect. Friction sounds are never present. Variation of the level of the liquid with change of the position of the patient from the vertical to the horizontal is nearly always determinable. Hydrothorax, meaning by this term a purely dropsical affection, is to be differentiated from double pleurisy with effusion. The history and symptoms, taken in connection with the signs, suffice for this discrimination.

Exceptional Physical Signs in Pleurisy.[1]—"The vocal fremitus may not be lost below the level of the fluid.

"Above the level of the fluid, over the compressed lung, there may be cavernous breathing and gurgling rales.

"A subcrepitant rale may be heard below the level

[1] Delafield: Lectures on the Practice of Medicine, 1903.

of the fluid, the level being demonstrated by the aspirator.

"Sacculated effusions give irregular physical signs which vary with the position of the fluid. The effusions are most easily made out if they are in contact with the wall of the chest.

"Most of the sacculated pleurisies I have seen have been situated about the root of the lung, gave the maximum flatness at some point between the scapula and the vertebral column, and were best aspirated at the point of maximum flatness. In some of these cases there was flatness and absence of breathing over the fluid; in some, flatness and bronchial voice and breathing; in some there was pulmonary resonance with bronchial voice and breathing over the lower part of the chest where there was no fluid."

PNEUMOTHORAX—HYDROPNEUMOTHORAX—PYOPNEUMOTHORAX.

In the rare cases of *pneumothorax,* that is, as distinguished from hydropneumothorax and pyopneumothorax, the physical conditions are the presence of air partially or completely occupying the thoracic space, and condensation of lung in proportion to the space occupied by air.

The diagnostic signs on the affected side are enlargement with decreased movability on respiration, and obliteration of the normal intercostal depressions, absent or displaced cardiac impulse, occasionally

distention of the right jugular vein in right-sided cases, frequently dyspnea on mild exertion; a purely tympanitic resonance over a portion or the whole of the affected side of the chest; suppression of the vesicular murmur, with notable diminution or suppression of vocal resonance and fremitus over a space in which tympanitic resonance is obtained. Over the compressed lung, if the condensation amount to complete or considerable solidification, and if adhesions hold the lung in contact with the chest wall at some point, there will be bronchial respiration and bronchophony; if the solidification be neither complete nor considerable, there will be bronchovesicular respiration with increased vocal resonance and fremitus. As a matter of fact, however, the lung when compressed is usually shrunken against the mediastinum and not directly accessible to percussion or auscultation. The accumulation of air may be sufficient to dilate the affected side, and restrain or annul the respiratory movements on this side. The appearances on inspection are then precisely the same as in the cases of chronic pleurisy and empyema, in which the affected side is dilated from the presence of liquid. Pneumothorax is, however, at once differentiated by the tympanitic resonance and by the abnormal decreased sense of resistance on percussion. If one side of the chest be more or less dilated, and the resonance over the side be purely tympanitic, the thoracic space must be filled, not with liquid, but with air. The intensity of the respiratory murmur

on the healthy side is increased. The heart is displaced toward the unaffected side of the chest. The area of cardiac flatness disappears in left-sided pneumothorax while in right-sided cases liver flatness is much decreased and resonance extends down to the level of the attachment of the diaphragm.

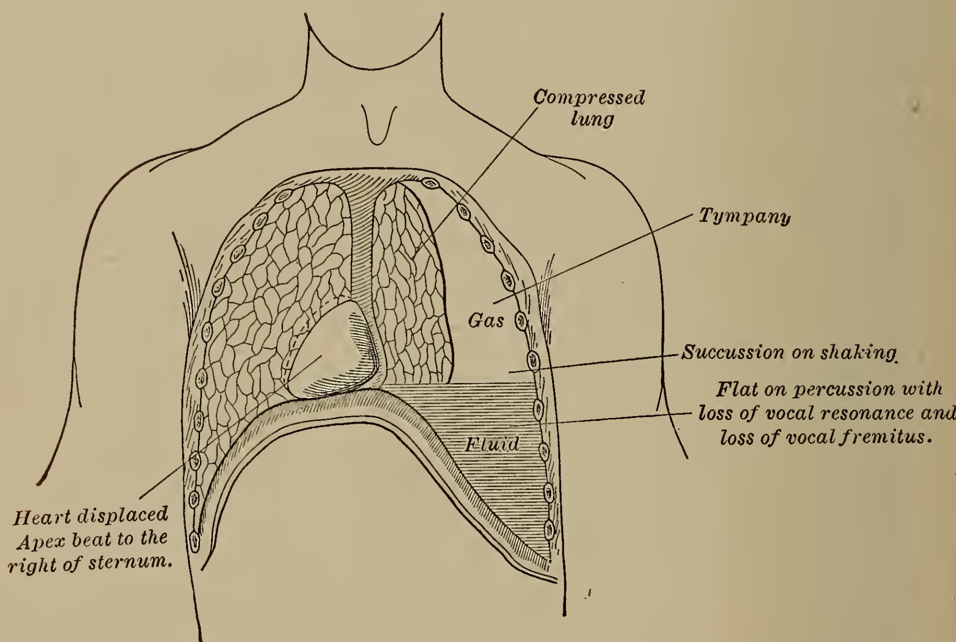


FIG. 13.—Left pyothorax. Metallic tinkling may be produced by the fluid dropping from the apex of the chest into fluid below. (After Maydl.)

In the great majority of cases in which the pleural cavity contains air there is also present more or less liquid which may be serous or purulent. The affection is then known as *hydropneumothorax* if the liquid

be serous, and *pyopneumothorax* if it be purulent. The physical conditions are the same as in pneumothorax, with the addition of the presence of liquid. The relative proportions of liquid and air in different cases are variable, and, also, in the same case at different periods.

The physical diagnosis of hydropneumothorax and of pyopneumothorax, as distinguished from pneumothorax, embraces the signs of liquid, in addition to those of air, within the pleural cavity. If the quantity of liquid be large or considerable, percussion at the base of the chest gives flatness, extending upward more or less, and tympanitic resonance above, the patient either sitting or standing. A change from the vertical to the horizontal position invariably causes variation of the upper limit of the flatness, inasmuch as the liquid and air change their relative situations without an exception. The level of the liquid follows completely the laws of gravity, in contrast to the relatively slight shifting dulness and the S-shaped Ellis line where fluid alone is present. The quantity of liquid is determined approximately, by ascertaining the space over which the flatness on percussion extends. The line which divides the flatness and the tympanitic resonance does not accurately denote the level of the liquid, because tympanitic resonance is transmitted a certain distance below this level, hence it is always to be assumed that the level of the liquid is somewhat higher than the upper boundary of the flatness.

In either pneumothorax, hydropneumothorax, or pyopneumothorax a group of *special auscultatory signs* is often found which are highly diagnostic, indeed almost pathognomonic. These signs are amphoric respiration, amphoric voice or echo, metallic tinkling, and the coin sound. The amphoric and the tinkling sounds may be present, either without the other, but they are not infrequently associated. Both signs are absent in some cases and they are not present in the same case at all times; their absence, therefore, by no means excludes the affections, and they are not essential to the diagnosis. When present they denote either air, or air and liquid, in the pleural cavity with perforation of lung, or a large phthisical cavity. Their occurrence in the latter is comparatively rare, and whenever they are associated with other signs already stated, their diagnostic import is demonstrative.

The *coin sound* consists in a distinctive bell-like quality given to the sound heard through the affected chest when a coin is tapped sharply against another held firmly in contact with the chest wall. The sound produced, instead of being distant and muffled as through a normal lung, is clear, intense, ringing, and can be likened to the sound a small pebble makes when dropped into a deep well. Absence of coin sound does not exclude pneumothorax.

Hydropneumothorax or pyopneumothorax may almost invariably be diagnosed instantly by the presence of a *succussion sound.* Whenever distinct splashing is produced by succussion and referable to

the chest, that is, not produced within the stomach, it is demonstrative of the presence of air and liquid within the pleural cavity.

ACUTE LOBAR PNEUMONIA.

In the *first stage* of this disease there is an abnormal accumulation of blood within the vessels of the affected lobe (active congestion or hyperemia), with some exudation within the air vesicles and bronchioles. Generally there is some exuded fibrin upon the pleural surface, due to circumscribed dry pleurisy. In most cases there is also circumscribed bronchitis, which is limited to the tubes within the affected lobe. In the *second stage* there is solidification due to the increase of exudation within the air vesicles. The solidification, at first limited, extends either rapidly or slowly, as a rule, over the whole lobe. Exceptionally more or less liquid effusion into the pleural cavity takes place (pleuropneumonia), the pleurisy then extending beyond the limits of the affected lobe. In this stage the pneumonia may involve either another lobe of the lung primarily affected, or a lobe of the opposite lung, and sometimes the disease, by successive invasions, extends over the whole of one lung, together with a lobe of the opposite lung. The pneumonia, in these secondary invasions, is usually accompanied by pleurisy and bronchitis.

In the *stage of resolution* the solidification of the

affected lobe or lobes decreases, sometimes rapidly and sometimes slowly, until the normal condition is restored. If resolution does not take place, the consolidated area becomes gradually organized by ingrowth of fibroblasts. Exceptionally pus is collected in a cavity, or in cavities within the lung constituting pulmonary abscess, or quite frequently within the pleura producing empyema.

The physical diagnosis of acute lobar pneumonia in the first stage can be frequently made by inspection alone. The flushed, frequently slightly cyanotic face, the presence of herpes about the mouth, increased respiration with inspiratory dilatation of the ali nasi, and frequent flinching of the patient with each expiration are signs of great significance. While if the inspection of sputum cups be permitted in physical diagnosis, the most reliable of all signs of pneumonia, and sometimes the earliest sign, may be found—the tenacious, slightly reddish or yellowish, sometimes prune-juice-colored expectoration. Localization of the process at this stage may be suggested by decreased respiratory motion on one side but must be based on the presence of the crepitant rale, with moderate or slight dulness on percussion, and diminished vesicular respiratory murmur over the affected lobe. There is sometimes in this stage a pleuritic rubbing sound over the affected lobe. The crepitant rale is not always present, and hence the affection cannot be excluded by the absence of this sign. When present, taken in connection with the symptoms, this sign is

of great diagnostic value. It is important not to mistake for this sign fine bubbling, or the subcrepitant rale. When the crepitant rale is wanting, a positive physical diagnosis must be deferred until more or less of the affected lobe becomes solidified, that is, when the disease passes into the second stage.

In certain cases the signs of slight dulness with decreased breath sounds are alone present for a considerable period. Indeed, bronchial breathing may never appear. Such cases have been called *central pneumonias* on the supposition that the process was at that stage limited to the region of the root of the lung, and extended slowly to the surface. Recent investigation by the *x*-ray has, however, shown that they originate at the surface; but, until they have extended to the large bronchi at the root, the bronchial sounds are not well transmitted.[1]

The physical signs of the "first stage of pneumonia" are therefore the signs occurring, not merely in the stage of engorgement, but up to the stage when consolidation extends from the surface of the lung to the large bronchi at the root.

The diagnosis in the *stage of hepatization* is to be based on the signs of solidification furnished by auscultation and percussion. The auscultatory signs are the bronchovesicular, followed by the bronchial respiration; increased vocal resonance, followed by bronchophony, and increased bronchial whisper, followed by

[1] Mason: Am. Jour. Dis. Child., March, 1916, xi.

whispering bronchophony. The signs of solidification are manifested at first within a circumscribed space, situated over either the upper, the lower, or the middle portion of the affected lobe, and either rapidly or slowly the signs extend, in most cases over the entire lobe. The crepitant rale, if it has been present in the first, generally disappears in the second stage. Sometimes, however, it is not entirely lost in this stage. The bronchovesicular respiration, increased vocal resonance, and increased bronchial whisper are present when the solidification is slight or moderate; the bronchial respiration, bronchophony, and bronchophonic whisper take their place when the solidification becomes considerable or complete. The latter signs, as a rule, speedily follow, inasmuch as the solidification in most cases quickly becomes complete or considerable. The foregoing three signs, denoting considerable or complete solidification, are usually present. Bronchial respiration, however, is sometimes present without bronchophony, and *vice versa*. Either, present alone, suffices to show the existence and the extent of the solidification. Moist bronchial or bubbling rales are sometimes, but rarely, heard over the affected lobe.

There is notable dulness on percussion in the second stage. The dulness may approximate and even amount to flatness. If a single lobe be affected, the dulness or flatness extends over a space corresponding to that occupied by the lobe or the portion of it which is solidified. In the anterolateral aspects

of the chest, the dividing line between the solidified and the healthy lobe is readily ascertained by percussion. The line thus obtained is not, however, identical with the normal interlobar line (*vide* p. 69), for the affected lobe distended with exudate is larger than normally.

Whenever one lobe of a lung is affected, the resonance over the unaffected part of the same lung is abnormally increased, the pitch is raised, and the quality is vesiculotympanitic. Vesiculotympanitic resonance, in other words, is produced, as over pleural effusions, because the unaffected lobe is relaxed (*vide* p. 101). This renders more marked the contrast between dulness over the solidified, and resonance over the healthy, lobe.

Over a portion of an upper lobe in the second stage, instead of notable dulness or flatness, there may be marked tympanitic resonance. This resonance proceeds from air within the trachea and the bronchi exterior to the lungs, the lung substance being completely solidified; it is chiefly or especially marked over the site of these air tubes (*vide* Williams' *Tracheal Tone,* p. 105). In some cases the tympanitic resonance has either the cracked-metal or the amphoric intonation. These signs *per se* might suggest either pneumothorax or phthisical cavities; the associated respiratory and vocal signs, however, show only solidification of lung. In cases of pneumonia affecting the left lung, a tympanitic resonance is not infrequently propagated from the stomach more or less upward over the affected

side of the chest. This may be readily traced to the stomach. On the right side a tympanitic resonance is sometimes propagated a certain distance upward from the transverse colon.

The commencement of the *stage of resolution* is denoted by a bronchovesicular respiration. The first change observed is the presence of a little vesicular quality in the inspiratory sound. When this is observed, the respiration is no longer bronchial, but has become bronchovesicular, although the pitch is still high, and the expiration is prolonged, high, tubular. This slight change shows that air begins to enter the pulmonary vesicles. As resolution goes on, more and more of the vesicular takes the place of the tubular quality in the inspiratory sound, and the pitch is lowered in proportion; the expiratory sound becomes proportionately less and less prolonged, its pitch lowered, its quality less tubular, until, at length, the normal characters of the respiratory murmur are regained. Resolution is then complete.

While the bronchovesicular respiration is undergoing the modifications just stated, the vocal sounds have corresponding changes. Bronchophony persists for some time after the respiration has become bronchovesicular, and then disappears, increased vocal resonance generally taking its place and persisting until resolution is completed. The bronchial whisper loses its bronchophonic characters, and is simply increased until its normal characters are regained. While the solidification is complete, the vocal fremi-

tus may, or may not, be increased. It is sometimes diminished. When, however, resolution has so far progressed that bronchophony is lost, the fremitus is usually greater than in health, and so continues, but progressively lessening until the solidification entirely disappears.

During the progress of resolution, the dulness on percussion diminishes in proportion as air enters the air vesicles. If tympanitic resonance have been present over the upper lobe, this gives place to a vesicular resonance. Some dulness, however, remains after the completion of resolution, and persists until the exuded fibrin on the pleural surface is absorbed. The amount of dulness remaining when the respiratory and vocal signs denote resolution, is proportionate to the quantity of exudation incident to the associated pleurisy.

In this stage the crepitant rale not infrequently returns, if it has entirely disappeared during the second stage, and if it has persisted, it is more marked and diffused. It is now known as the returning crepitant rale. More frequently the rale in this stage is a fine bubbling or the so-called subcrepitant. Both rales are not infrequently associated, and, from the distinctive characters of each, they are readily distinguished. Moist rales, more or less fine or coarse, are not infrequent. The pitch of these rales remains more or less high until the solidifying exudation is completely absorbed.

If the affection pass into the stage of *delayed reso-*

lution the respiratory sounds are more or less of the bronchial characters. Bubbling bronchial rales, coarse and fine, are abundant. Weak bronchophony may persist, or the vocal resonance may be diminished. Fremitus may, or may not, be increased. Notable dulness or flatness on percussion remains. The majority of cases spoken of clinically as delayed resolution are in reality small encapsulated empyemas, while occasional cases turn out to be acute pneumonic phthisis.

If the pneumonia result in pulmonic abscess, there will be notable dulness or flatness on percussion within a circumscribed space, together with absence of respiratory murmur, and diminished or suppressed vocal resonance. These signs warrant a probable diagnosis which is corroborated by the sudden expectoration of pus in a considerable quantity. The signs just stated may then be followed by those denoting a cavity—namely, cavernous respiration and whisper, with intense vocal resonance.

CIRCUMSCRIBED PNEUMONIA—EMBOLIC PNEUMONIA—HEMORRHAGIC INFARCTUS OR PULMONARY APOPLEXY.

The form of pneumonia known as lobular pneumonia, occurring in children, has been considered (*vide* Bronchitis Seated in Small-sized Tubes). Whenever circumscribed, as a rule, pneumonia is secondary

to some other pulmonary affection. Circumscribed pneumonia, giving rise to an intravesicular exudation, which may disappear readily by resolution or absorption, is not very infrequent in cases of phthisis. The signs are those which represent solidification of lung within an area more or less circumscribed; but the differentiation, from the solidification due to phthisis, can only be positively made, after the signs have shown that the solidification has notably diminished, or disappeared.

In embolic pneumonia there may be dulness on percussion, with feeble bronchial or bronchovesicular respiration, or suppression of respiratory sound, weak bronchophony or increase of vocal resonance, within a circumscribed space, or spaces, generally on the posterior aspect of the chest, and oftenest on the right side. These signs, taken in connection with symptoms and pathological conditions consistent with the supposition of emboli received into the right side of the heart, namely, when the pulmonary symptoms follow puerperal disease, ulcers, wounds, injuries, or venous thrombosis, render the diagnosis quite positive. If, however, the pulmonary affection consists of small disseminated nodules, the foregoing signs will not be present. The diagnosis then must be based on the history and symptoms, taken in connection with the exclusion of other pulmonary affections by the absence of signs, which should be present if they existed. Bubbling rales, the pitch more or less raised, at different situations may indicate the probable sites of the nodules. There may

be pleuritic friction sounds. The signs may show, as a complication, pleurisy with effusion.

Extravasation of blood (pneumorrhagia), if it be in small spaces, give rise to no definite physical signs. If, however, extravasation extend over a considerable space, there will be dulness on percussion, with feeble or suppressed respiratory sound within an area corresponding to the extent of the extravasation. Within, and near this area, there will be likely to be moist bronchial rales more or less fine or coarse.

PULMONARY GANGRENE.

In diffused pulmonary gangrene the physical signs are those of solidification extending over the greater part or the whole of a lobe. The diagnosis, however, can only be made when, in connection with these signs, there are present the characteristic fetor of the breath and expectoration.

In circumscribed gangrene there is dulness or flatness on percussion within an area corresponding to the extent of the affection, with either suppression of respiratory sound or bronchial respiration, and the vocal signs of solidification. Within and near this space moist bronchial rales, more or less raised in pitch, are likely to be heard. The situation is usually on the posterior aspect of the chest. These signs do not suffice for a positive diagnosis without the characteristic breath and expectoration. Cavernous signs may appear after the gangrenous portion of lung has sloughed away and been expectorated.

PULMONARY EDEMA.

The physical condition expressed by the term pulmonary edema is the presence of effused serum within the air vesicles. With this condition is associated more or less pulmonary congestion.

In cases of pulmonary edema developed rapidly and largely in connection with renal disease, with obstruction at the mitral orifice of the heart, or with both these affections combined, giving rise to great dyspnea, and liable to end speedily in death, the following are the *diagnostic signs:* Dyspnea, with increasing cyanosis; dulness on percussion on both sides of the chest, especially over the lower lobes, fine bubbling or so-called subcrepitant rales diffused over the chest on both sides, together with coarser bubbling sounds, and the murmur of respiration notably weak or suppressed over the lower lobes. Inasmuch as the lungs are not solidified the rales are low in pitch. The vocal signs of solidification are, of course, wanting. Occasionally the crepitant rale is mingled with the fine bubbling sounds.

This form of the affection is to be differentiated from hydrothorax with large effusion, and from so-called capillary bronchitis. Hydrothorax is always associated with more or less anasarca, or general dropsy, whereas, pulmonary edema, even when dependent on renal disease, may occur without dropsical effusion elsewhere. Moreover, the presence of liquid within the pleural cavities, and its amount,

may always be determined demonstratively in cases of hydrothorax (*vide* Pleurisy with Effusion and Hydrothorax). Capillary bronchitis occurs chiefly in children. The so-called subcrepitant rale on both sides of the chest is the diagnostic sign of this affection, but it is not accompanied by dulness on percussion, except in so far as the bronchitis may be associated with lobular pneumonia or collapse of pulmonary lobules. The rapid development of the edema and its pathological connections are diagnostic points to be taken into account.

Pneumonia is excluded by the fact that the affection is at the beginning bilateral, and by the absence of the signs of solidification of lung.

Pulmonary edema less in degree and diffusion, has, of course, the same signs, not as marked and not as extensive—namely, dulness on percussion and fine bubbling sounds or the so-called subcrepitant rales. In this form the affection is bilateral, and seated especially in the posterior and inferior portions of the lungs. Moreover, this form has the same pathological connections, namely, with disease of the kidneys, and mitral lesions of the heart. The low pitch of the bronchial rales, and the absence of the respiratory and vocal signs of solidification, together with the fact of the affection being bilateral, and the coexistence of disease of the heart or kidneys, constitute the basis of a positive diagnosis.

Hypostatic congestion of the lungs may occasion a certain amount of pulmonary edema. The physi-

cal diagnosis is to be based on bilateral dulness on the posterior aspect of the chest, with low-pitched, fine bubbling sounds, or the so-called subcrepitant rales on both sides, these signs occurring under circumstances which lead to the supposition of this form of congestion.

NEOPLASMS OF LUNG—TUMORS WITHIN THE CHEST.

Neoplastic growths in the lungs are usually in the form of nodules varying in size from that of a pea to a hen's egg, disseminated throughout one lung or both lungs, in greater or less numbers. These disseminated nodules, if of small size, have no well-marked, definite diagnostic signs. If limited to a lung, or if greater in number in one lung, they may occasion an appreciable dulness on percussion. They may also occasion feebleness of the respiratory murmur, and, owing to coexisting circumscribed bronchitis, moist bronchial rales may be heard at different points. These signs warrant a diagnosis when, as is usually the case, cancer is known to have existed elsewhere. With reference to diagnosis, it is to be borne in mind that, when cancer of the lung is secondary, both lungs are affected, and, when it is primary, the affection is generally unilateral.

If there be nodules of considerable size, there will be well-marked dulness on percussion in different situations, and the signs of solidification may be

present, namely, either bronchial or bronchovesicular respiration, either increased vocal resonance or bronchophony, and increased vocal fremitus.

In some cases of unilateral carcinoma, the greater part, or the whole, of a lung may be infiltrated with the morbid growth, increasing its volume and giving rise to enlargement of the affected side, diminished respiratory movements or immobility, flatness on percussion, with diminished or suppressed respiratory murmur, vocal resonance, and fremitus. If, as is usual, there be also more or less pleuritic effusion, the intercostal spaces may be pushed out to a level with the ribs. Here are the signs which denote chronic pleurisy with large effusion, and the differential diagnosis cannot be made with positiveness until the fluid within the chest be withdrawn, and it be found that, irrespective of the bulging of the intercostal spaces, the physical signs remain. Exploration with a small trocar, or hollow needle, will settle the diagnosis when there is no pleuritic effusion.

In other cases the neoplastic growth induces contraction of the lung, diminishing its volume, and causing notable diminution of the affected side. The appearances on inspection are those which denote contraction after chronic pleurisy, and they may be present also in cases of fibroid phthisis or cirrhosis of lung. The differential diagnosis must be based chiefly on diagnostic points relating to the history and symptoms.

Tumors within the chest, generally having their

points of departure in the mediastinum, displace the lung in proportion to their size. They may cause considerable displacement of the heart, and produce more or less enlargement of the chest with diminished respiratory movements. Enlargement of the subcutaneous veins, indicative of *venous obstruction, is more often to be observed in solid tumors than in aneurism.* Over the site of the tumor there will be either dulness or flatness on percussion. Generally, respiratory sound over the tumor is wanting, vocal resonance and fremitus being either diminished or suppressed. In the neighborhood of the primary bronchi and over lung compressed by the tumor, there may be bronchial respiration, with bronchophony and increased fremitus; while over portions of the lung not directly affected the breath sounds may be suppressed or stridulous as a result of bronchial obstructions. If the chest be enlarged, its enlargement is not likely to be as uniform as when it is dilated with liquid; this is a diagnostic point. The tumor, or the tumors, may not be confined to one side of the chest. It is to be borne in mind that pleurisy with effusion may exist as a complication, and this may serve to obscure the diagnosis.

The physical diagnosis involves differentiation from pericarditis with effusion and aneurisms. These affections are to be excluded by the absence of their diagnostic signs.

ACUTE MILIARY TUBERCULOSIS.

The physical condition in this affection is the presence of a large number of the small bodies known as tubercles or miliary granulations, disseminated throughout both lungs. Bronchitis is an associated affection, by no means constantly present.

If the tubercles be about equally distributed in the two lungs, there is no abnormal disparity of the resonance on percussion between the two sides of the chest. A comparison, also, of the two sides may afford no disparity as regards the respiratory murmur, vocal resonance, and fremitus. Moist rales, due to the associated bronchitis, may be present in different situations. A physical diagnosis, under these circumstances, cannot be made with positiveness. Physical exploration, however, is important in order to exclude other affections; and the negative result, taken in connection with the symptoms—hyperpyrexia, rapid pulse, accelerated breathing, cyanosis, etc.—renders the diagnosis extremely probable. The differential diagnosis involves discrimination from capillary bronchitis, and an essential fever with a bronchial complication. The affection has been repeatedly mistaken for typhoid fever.

The tubercles may be more abundantly distributed in one lung. A disparity in the resonance on percussion may then be apparent, and, perhaps, an abnormal increase of vocal resonance and fremitus. The discovery of a patch of partial consolidation at the

apex of one lobe, while not evidence of miliary tuberculosis, would strengthen the diagnosis by indicating the presence of a possible starting-point from which dissemination could have occurred. These signs, taken in connection with the symptoms, establish the physical diagnosis.

PHTHISIS.

For purposes of prognosis and treatment, the so-called Turban and National Association classifications of clinical stages of tuberculosis are superior to any previously used (*vide* p. 371); from the stand-point of physical diagnosis, however, a simpler division, based more upon the pathological stage, without regard to the extent of the lesion, is desirable. Except for the area involved, the signs obtained over a small apical lesion may, of course, be identical with those found in a wide-spread affection disseminated through all lobes. From a clinical stand-point, however, the former case would be incipient, and the latter severe.

With regard simply to the pathological stage at a particular point of the chest, we may conveniently discuss the physical diagnosis of pulmonary tuberculosis under three main groupings: (1) Cases in which the pulmonary affection consists of small areas of bronchitis and peribronchial consolidation—early stages; (2) cases in which the affection has moderately or considerably progressed so that the proportion of healthy tissue to consolidated areas is markedly decreased; (3) cases in which healthy alveolar tissue

is absent, or small in proportion to the caseating areas, and those in which cavities have formed.

In cases of *early phthisis* the essential physical condition is the presence of small solidified masses, or nodules, the intervening vesicular structure being little affected. These nodules vary from the size of a pea to a filbert. In the vast majority of cases they are situated at or near the apex of either the right or the left lung. Generally, circumscribed capillary bronchitis coexists in proximity to the nodules. An intercurrent circumscribed pneumonia sometimes occurs, giving rise to transient solidification within a limited area. Dry circumscribed pleurisy situated over the affected portion of lung generally occurs from time to time.

In the cases of a *moderate or a considerable pulmonary affection*, the difference, as compared with the preceding group of cases, consists in the presence of nodules of large size, or solidification from the phthisical deposit extending over a space, or spaces, sufficient in size to give rise to well-marked physical signs. The solidification in these cases may be extended by the development of circumscribed interstitial pneumonia. The circumscribed bronchitis is greater, as a rule, in degree and extent; attacks of dry pleurisy may continue to occur, and the pleural surface becomes adherent. In these cases, generally, the affection, existing primarily in one lung, now exists in both lungs. The volume of the lung first affected, at the summit, is more or less diminished. Enlargement

of the bronchial glands is usual, and these may be so situated as to press upon and diminish the calibre of one of the primary bronchi. In some cases portions of lung in the neighborhood of solidified masses or nodules are emphysematous (vicarious emphysema).

Cases of *advanced phthisis* are characterized by the presence of a cavity, or, commonly, of cavities, varying in number, size, rigidity or flaccidity of the walls, freedom of communication with bronchial tubes, and the nearness of their situation to the superficies of the lung. In cases of progressive phthisis, in addition to cavities, there is more or less solidification from phthisical exudation and interstitial pneumonia. The volume of the lung at the summit is often notably diminished. The pleural surfaces are firmly adherent. If, however, the disease has been retrogressive or non-progressive, there may be little or no solidification of lung, the cavity or cavities forming the only lesion. In cases of advanced phthisis, with very rare exceptions, both lungs are affected, and cavities often exist on both sides.

The physical diagnosis in cases of *early phthisis* embraces what may be called direct and accessory signs. The *accessory signs* are those which represent incidental affections—namely, circumscribed bronchitis, pleurisy, and pneumonia. The *direct signs* are those representing the essential condition, namely, the solidified masses or nodules.

In early cases the supraclavicular region may be found slightly retracted and the normal inspiratory

motion decreased on the affected side. In more advanced cases the retraction and limitation of motion is due to fibrous changes in the adjacent lung and pleura, but in the early stages there is reason to believe that local muscular spasm is the explanation. Pottenger, who particularly emphasizes this view, has also pointed out that over an incipient lesion palpation reveals tonic contraction of the scaleni and adjacent muscles, while in advanced cases atrophy of these muscles has occurred.

An important direct sign is *dulness on percussion.* Slight dulness on percussion at the summit of the chest, in front or behind, is a highly important sign, taken in connection with symptoms of incipient phthisis. In determining that a relative dulness is abnormal, the student must bear in mind, in the first place, the normal disparity between the two sides. The right side at the summit is relatively somewhat dull on percussion in healthy persons. Due allowance is to be made for this normal disparity. In the second place it is to be borne in mind that any deformity affecting the symmetry of the chest will affect the relative resonance on the two sides; and that a deviation from symmetry attributable to the position of the patient will occasion a disparity on percussion. In the third place the rules for the practice of percussion must be kept in mind in order to avoid producing apparently an abnormal disparity by the non-observance of these rules (*vide* p. 89 *et seq.*). Normal resonance on percussion on the two sides is

not, however, a strong point for the exclusion of incipient phthisis.

The *direct respiratory signs in incipient phthisis are more delicate diagnostic signs than is percussion.* In the earliest cases they consist of feeble breath sounds and later bronchovesicular respiration. To these is to be added a localized interrupted or wavy inspiratory murmur, as an occasional sign. Of course familiarity with the characters of the bronchovesicular respiration is indispensable—the combination of the vesicular and the tubular quality in the inspiratory sound, with the pitch raised in proportion to the amount of tubularity, and the expiratory sound more or less prolonged, high, and tubular. Not infrequently the only appreciable morbid modification is diminished intensity of the murmur. When this sign is present it is probable that the lack of intensity is the reason for the absence of the characters of the bronchovesicular modifications, that is, the latter sign would have been present were the respiratory sounds more intense.

The *direct vocal signs* in incipient phthisis are increased vocal resonance, increased whisper, and increased fremitus. The other direct signs may be present without an appreciable morbid increase of the vocal resonance or fremitus. The increased whisper may also be wanting, but more rarely than the two other vocal signs.

In deciding on the presence or absence of each and all of these direct signs, it is essential to know

and to judge correctly of the disparity between the two sides of the chest at the summit in health. Normally the resonance or percussion at the summit on the right side is slightly dull as compared with the left side; the inspiratory sound on this side has some tubularity in quality, and is somewhat raised in pitch; the expiratory sound may be more or less prolonged, high, and tubular; the vocal resonance on the right side is always greater, the same being true of fremitus; the whisper is louder on the right side, and the intensity of the respiratory murmur is a little less on this side.

Whenever it is a question as to a small phthisical affection at or near the apex of the right lung, it is a matter of experience and judgment to decide if the disparity in respect to these points be greater than normal, and it is not always easy to come at once to a decision. From the want of a proper appreciation of the several points of disparity in health, it is not uncommon for an erroneous diagnosis of phthisis to be based thereon. Appreciating the normal points of disparity, it is obviously easier to determine that the several direct signs of incipient phthisis are present at the left than at the right summit; relative dulness on percussion, bronchovesicular or weakened respiration, increased vocal resonance, whisper, and fremitus, at the left summit are, of course, always abnormal.

Corroborative evidence of incipient phthisis may be obtained by the presence of *accessory signs*. These are: (1) Fine bubbling or the so-called subcrepitant

rale at the summit on one side. This sign denotes a circumscribed capillary bronchitis, and this, at the summit on one side, is usually associated with phthisis. (2) A crepitant rale at the summit on one side denotes a circumscribed pneumonia which is usually secondary to phthisis. (3) A pleuritic friction sound limited to the summit on one side is evidence of a dry circumscribed pleurisy which occurs often in the early stage of phthisis. (4) Indeterminate rales, crumpling and crackling, are significant of phthisis if limited to the summit on one side. These rales, it is to be recollected, are sometimes found in healthy persons on forced breathing, especially if the binaural stethoscope be employed. If they be normal they are found on both sides. The accessory signs are not sufficient for a positive diagnosis if they exist alone; but they are to be considered as corroborating the evidence derived from the direct signs, together with the symptoms and history. It is of service often in bringing out the rales to cause the patient to cough at the end of expiration and then inhale deeply.

As regards differential diagnosis, the affections with which incipient phthisis is likely to be confounded are chronic bronchitis and moderate emphysema. With respect to the first of these affections—namely, bronchitis—it must be remembered that from a physical stand-point these early stages of tuberculosis are merely areas of bronchitis, with associated small bronchopneumonia nodules, due to a special organism. The tendency of that organism

to select certain areas of the lung; the chronicity of the process, and its slow extension so that the signs have a localized distribution, are more important characteristics than the actual signs obtained over any given point of the chest. Slight dulness with subcrepitant rales, and decreased or bronchovesicular breath sounds limited to one apex are characteristic of tuberculosis, while the same signs limited to the bases suggest chronic passive congestion of the lung from mitral disease; or if present uniformly throughout the chest are usually indicative of an acute bronchopneumonia. In cases of considerable duration the tendency of tubercular consolidations either to caseate or else heal by fibrosis, instead of resolution, leads to such signs as altered resonance, modified voice and breath sounds which are not present in simple chronic bronchitis.

The physical signs in cases of moderate emphysema sometimes lead to the error of supposing this affection to be phthisis. Owing to the relatively greater intensity of the resonance on percussion at the left summit, dulness is thought to exist at the right summit; and a prolonged expiration, with the normally greater vocal resonance at the right summit, are regarded as signs of phthisis. This error may be avoided by a careful study of the signs of emphysema, and the normal disparity in respiration, vocal resonance, and fremitus, existing between the two sides of the chest.

The physical diagnosis of a phthisical affection which is considerable or moderate in amount, is, in

most cases, an easy problem. Inspection often furnishes marked signs. The upper anterior portion of the chest on one side is depressed or flattened, and the superior costal movements of respiration are diminished, the chest elsewhere being symmetrical in both size and motions. There is more or less marked dulness on percussion at the upper part of the chest on the affected side. Sometimes the diminished resonance is tympanitic in quality (tympanitic dulness) without the existence of cavities, the resonance being transmitted from the primary and secondary bronchial tubes. The respiration is either bronchial or bronchovesicular approximating more or less to the bronchial. Occasionally, however, the respiratory sounds are too feeble for their characters to be appreciated. There is either bronchophony, or the vocal resonance is notably increased without the bronchophonic characters. The whisper is either distinctly bronchophonic or it is notably increased in intensity, high in pitch, and tubular in quality. Vocal fremitus is often increased. Moist bronchial rales, coarse or fine, are generally present. With these diagnostic signs on one side, the signs of a smaller amount of disease are generally present on the other side.

In some cases of a moderate phthisical affection, the judgment may be confused by the resonance on percussion being increased or vesiculotympanitic on the affected side. This sign denotes the coexistence of emphysematous lobules (vicarious emphysema) developed in the progress of phthisis. The diagnosis

of the latter affection is then to be based on the signs obtained by auscultation.

In advanced phthisis the physical diagnosis of the disease is easy. The signs distinctive of this stage of the disease are those which denote pulmonary cavities—namely, tympanitic resonance on percussion within a circumscribed space; cracked-metal or amphoric resonance; cavernous respiration; cavernous whisper and sometimes pectoriloquy; amphoric respiration and voice, and gurgling (*vide* Chapter VI for description of these signs).

The cavernous signs are generally associated with the signs of solidification. In some cases, however, in which the disease has been non-progressive and retrogressive, the cavernous signs are present without the signs which denote solidification of lung.

FIBROID PHTHISIS—INTERSTITIAL PNEUMONIA, OR CIRRHOSIS OF LUNG.

In this affection the physical conditions are, solidification from hyperplasia of the interstitial pulmonary tissue, dilatation of bronchial tubes (bronchiectasis), and diminished volume of the lung affected. The affection, as a rule, is either limited to, or especially marked on, one side. The whole of a lung, or only a portion of it, may be affected. Bronchitis always coexists.

There is notable dulness on percussion, the diminished resonance being sometimes tympanitic. The

degree of resonance may vary at different examinations, owing to differences in the amount of morbid products within the bronchial tubes. The respiration is bronchial, or bronchovesicular. At times, from obstruction of bronchial tubes, it may be suppressed. Bronchophony and increased vocal resonance are the vocal signs, together with the corresponding whispering signs. The side of the chest which is chiefly or exclusively affected becomes contracted either entirely or in part, resembling in this respect the appearances after chronic pleurisy. The heart is frequently drawn toward the affected side.

With these signs the affection is to be differentiated from the ordinary form of phthisis by reference to points pertaining to the symptoms and history.

DIAPHRAGMATIC HERNIA.

The presence of more or less of the abdominal viscera within the thoracic cavity in consequence of a congenital deficiency of a portion of the diaphragm, or perforation from accidents, or enlargement of the natural openings, gives rise to certain anomalous signs—namely, a tympanitic resonance, variable at different times owing to differences as regards the quantity of gas within the viscera; absence of the respiratory murmur from the base of the chest upward, the height proportional to the space occupied by the abdominal organs, and the

intestinal sounds emanating from within the chest, not conducted from below.

This extremely rare affection can only be confounded with pneumothorax, or a pleural effusion, when the stomach is full of food.

The use of the *x*-ray is invaluable in this condition, and gives positive evidence as to the physical relations of the diaphragm and the abdominal and thoracic viscera.

CHAPTER VIII.

THE PHYSICAL CONDITIONS OF THE HEART IN HEALTH AND DISEASE. THE HEART SOUNDS AND CARDIAC MURMURS.

Physical conditions of the heart in health: Boundaries of the precordia—Normal situation of the apex beat—Boundaries of the deep and of the superficial cardiac space—Relations of the aorta and the pulmonary artery to the walls of the chest—The heart sounds—Characters distinguishing the first and the second sound—Mechanism of the production of the heart sounds—Auscultation of the pulmonic and the aortic second sound separately—Movements of the auricles and ventricles in relation to each other—Physical conditions of the heart in disease: Enlargement of the heart—Hypertrophy and dilatation—Abnormal impulses of the heart, and modifications of the apex beat—Valvular lesions—Roughness of the pericardial surfaces—Liquid within the pericardial sac—Abnormal modifications of the heart sounds—Reduplication of heart sounds—The pulse—Frequency of pulse—Regularity of pulse—Size of pulse—Rapidity of pulse—Tension of pulse—Character of arterial wall—Capillary pulsation—Pulsation of the cervical veins—Cardiac murmurs—Normal and abnormal blood currents within the heart, and their relations with the heart sounds—Mitral direct murmur—Flint murmur—Mitral regurgitant murmur—Mitral systolic murmurs of functional and cardio-respiratory origin—Aortic direct murmur—Aortic regurgitant murmur—Aortic diastolic non-regurgitant murmur—Coexisting endocardial murmurs—Tricuspid direct murmur—Tricuspid regurgitant murmur—Pulmonic direct murmur—Pulmonic regurgitant murmur—Facts of practical importance in relation to endocardial murmurs—Pericardial or friction murmur.

Before entering upon the study of the physical diagnosis of the disease of the heart the student

must be familiar with its anatomy and physiology. The plan of this work embraces the anatomical relations of the heart and the space which it occupies within the chest, as physical conditions of health determinable by normal signs, together with the heart sounds. Having briefly stated these conditions of health, the morbid physical conditions which may be ascertained by percussion, auscultation, and other methods of physical exploration, will be considered.

THE PHYSICAL CONDITIONS OF THE HEART IN HEALTH.

The Precordia.—The area on the surface of the chest corresponding to the space which the heart occupies within the chest is the precordial region, or the precordia. The upper, lower, and two lateral boundaries of this region must be memorized. The upper boundary is the third rib, the lower is a horizontal line passing through the fifth intercostal space; the left lateral boundary is at or a little within the left midclavicular line, and the right lateral boundary is represented by a vertical line situated about a finger's breadth to the right of the right margin of the sternum. As the volume of the heart varies, within certain limits, in different healthy persons, the boundaries of the precordia are, of course, not always exactly the same. The foregoing statements are sufficiently accurate for practical purposes.

The horizontal line representing the lower bound-

ary of the precordia intersects the point where the apex beat of the heart is felt. In most healthy persons the apex beat is felt, and frequently seen, in the fifth intercostal space, a little within the midclavicular line. This is assuming the persons to be sitting or standing. In recumbency on the back the beat sometimes rises to the fourth intercostal space, and it is sometimes found in the fourth space in the sitting or standing position of the body. The distance from the midclavicular line varies in different healthy persons; it is sufficiently accurate to say it is a little within that line (Fig. 14).

In changing a patient from the left lateral recumbent to the right lateral position, it may be determined by palpation and percussion that the apex of the heart moves $\frac{1}{2}$ to $1\frac{1}{2}$ inches to the right in healthy people.

The use of the orthodiagraphic method of examining the heart in action has brought about a readjustment of our ideas as to the probable accuracy of topographical percussion of the heart. Although percussion will still be considered a necessary and useful method of examining the heart, the highest standard of accuracy will demand the use of the orthodiagram.

The Apex Beat.—In speaking of the apex of the heart we refer to the most lateral point at which a definite impulse can be felt; in sharp contrast to the point of maximal impulse (P. M. I.) which is inside the true apex.

The force of the apex beat varies much in different healthy persons, owing to other causes than the power of the heart's action, such as the amount of muscular substance and fat in that situation, the width of the intercostal space, the convexity of the chest, the relation to the left lung, etc. Allowance is to be made for these variations in determining the abnormal modifications of the force of the beat.

The Superficial and Deep Cardiac Space.—Within a portion of the precordia the heart is uncovered by lung, and in the remaining portion lung intervenes between the heart and the walls of the chest. The former of these portions is called the superficial and the latter is called the deep cardiac space. The superficial cardiac space on the right side extends to the median line. On the left side the lung recedes at a point on the median line on a level with the cartilage of the fourth rib, and the anterior border of the upper lobe makes an outward curve, returning inward at or near the apex of the heart. This leaves the heart uncovered within an area which, for practical purposes, may be represented by a right-angled triangle, the hypotenuse extending from the median line on a level with the costal cartilage of the fourth rib to the apex of the heart; the right angle formed by the median line and the horizontal line which forms the lower boundary of the precordia (Figs. 14 and 15).

The lateral limit of the superficial cardiac space may be easily defined by percussion. It is only necessary to ascertain the curved line formed by the receding

anterior border of the upper lobe of the left lung. A distinct, although not great, dulness on percussion marks this border of the lung. The border of the lung is as distinctly marked by the abrupt diminu-

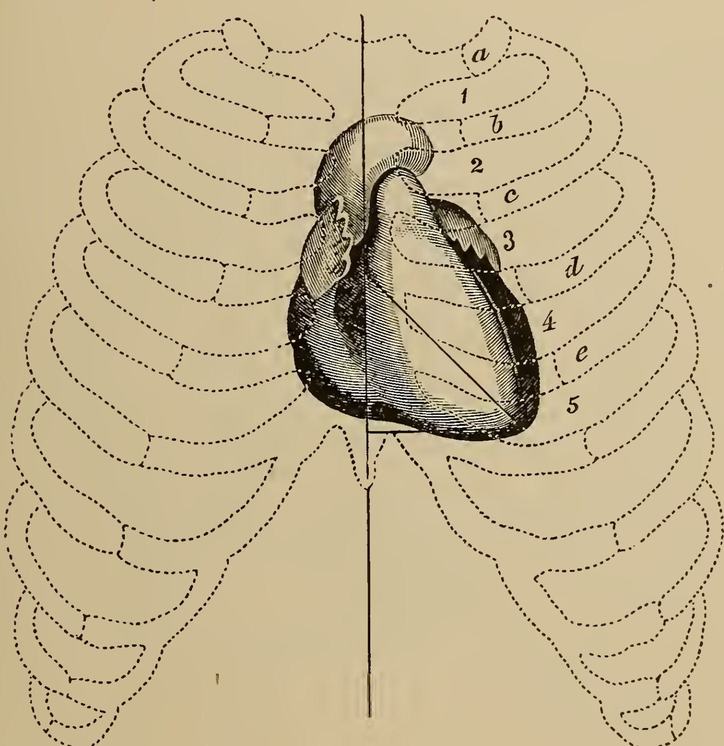


Fig. 14

tion of the vocal resonance, if auscultation be made with the stethoscope. Percussion of the right border of the superficial cardiac space is unsatisfactory because the sternum not only contributes its own resonance but also conducts the percussion stroke later-

ally to lung not immediately beneath the finger (*vide* p. 29). The area of flatness obtained, therefore, is smaller than the true superficial cardiac space, being bounded on the right by the left sternal margin.

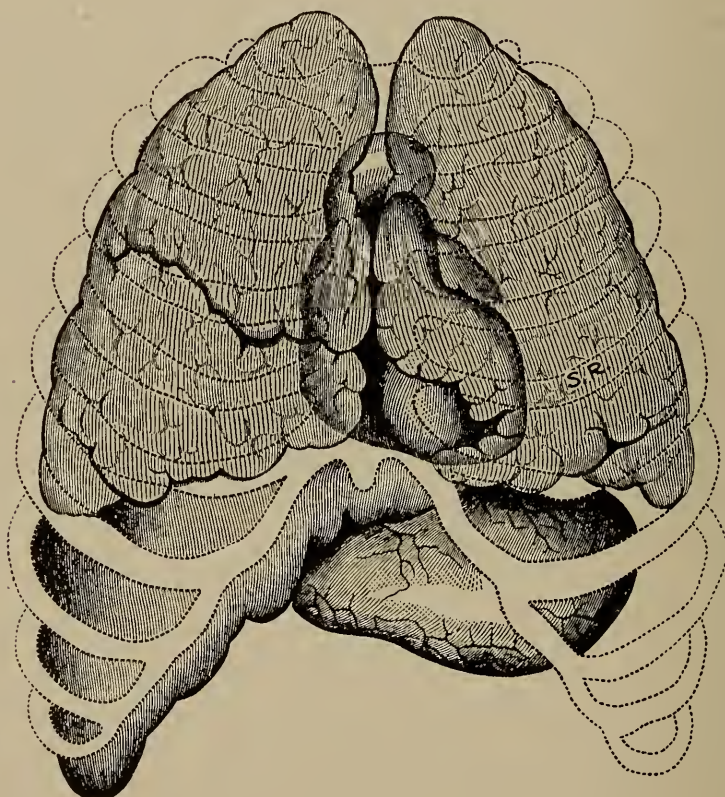


Fig. 15

This lack of power to determine accurately the superficial cardiac area is not as important as one might suppose. For the right border of cardiac flatness is shifted toward the right when the superficial area is

enlarged by cardiac dilatation or pericardial effusion. In other words, the area of flatness is an indication of an increased or decreased superficial space, even though it never corresponds exactly to the size of that space. The outer boundaries of the deep cardiac space may also be determined by percussion. Distinct, though slight, dulness marks the limits of the precordia. Defining thus the boundaries of the precordia and of the superficial cardiac space in healthy persons makes a good practical exercise in percussion. Distinct, though slight, dulness may usually be made out in the fourth space to the right of the sternum as far as three-quarters of an inch from the sternal border.

Relations of the Aorta and Pulmonary Artery to the Wall of the Chest.—The base of the heart, especially in connection with auscultatory signs, is generally considered to be at the second intercostal space near the sternum, although in reality it lies at the level of the third intercostal space (Fig. 16, p. 258). In the right and left second intercostal spaces sounds produced at the aortic and the pulmonic orifice are best studied, either in health or disease. With reference to these sounds, the anatomical relations of the aorta and the pulmonary artery to the right and the left second intercostal space are of importance. If the stethoscope be applied in the second intercostal space on the right side, close to the sternum, it is very near the aorta, and sounds produced at the aortic orifice are transmitted along the vessel and best heard in this situation. If the stethoscope be applied in the

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second intercostal space on the left side, it is very near the pulmonary artery (*vide* Figs. 14 and 16), and here the sounds produced at the pulmonic orifice are loudest.

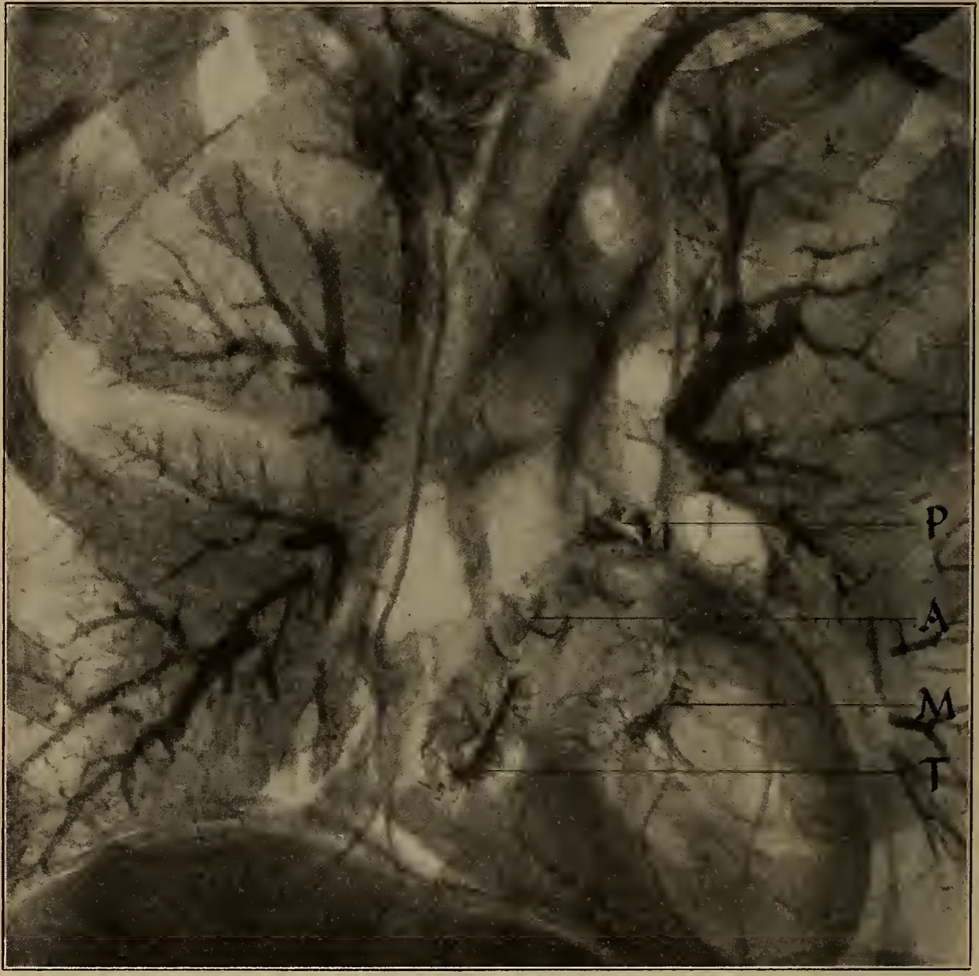


FIG. 16.—Topography of the heart valves. *P*, pulmonary; *A*, aortic; *M*, mitral; *T*, tricuspid valve. They are more widely separated than usually found; the condition being probably due to cardiac dilatation. (Norris and Fetterolf.)

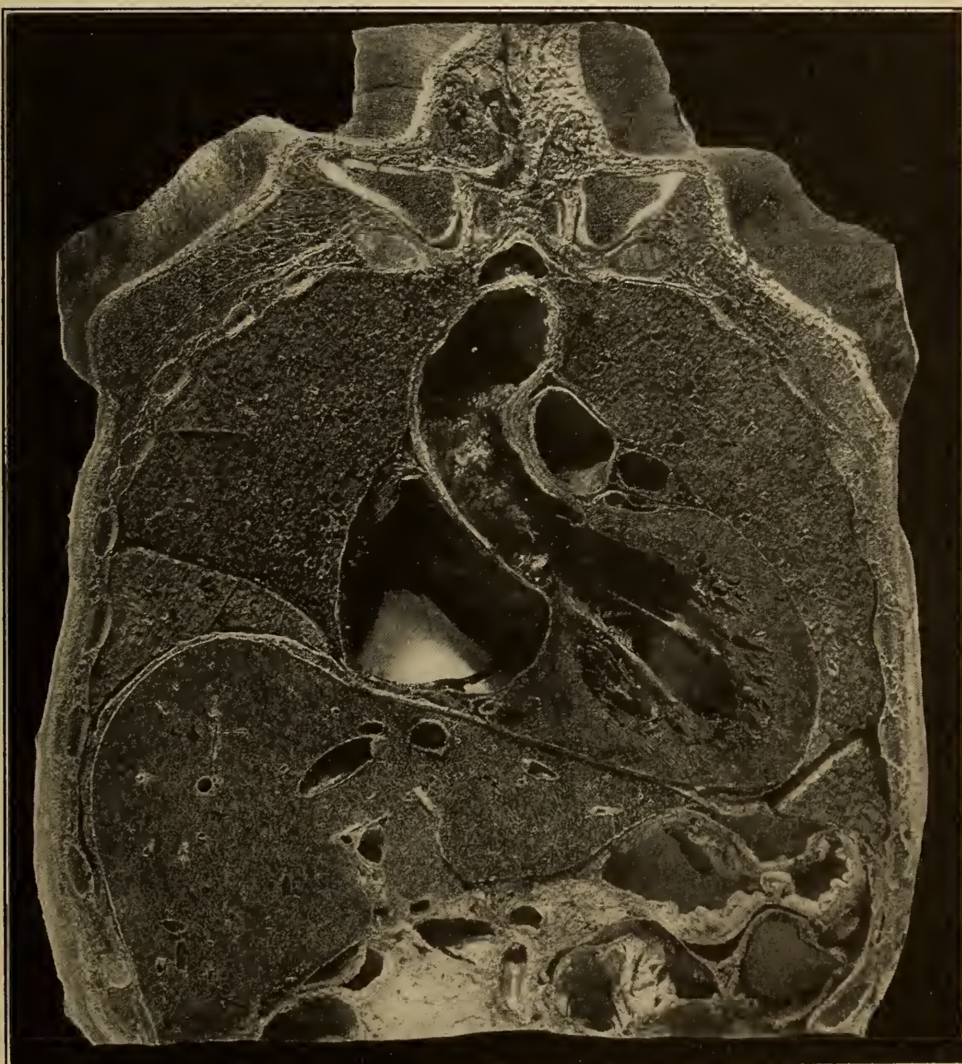


Fig. 17.—Frontal section of the thorax, showing right auricle, left ventricle, the pulmonary artery cut across, and the ascending aorta. The fissure between right upper and middle lobe is incomplete. (Norris and Fetterolf.)

The Heart Sounds.—It is customary to consider the heart sounds as two in number, and to distinguish them as the first (S I) and the second sound (S II). The characters which distinguish the heart sounds in health are to be studied preparatory to the study of the abnormal modifications, which are important physical signs of disease. It is essential to be able always to make the distinction between the so-called first and the second sound in order to connect with them separately cardiac murmurs. The conventional use of the term heart sounds, as distinguished from cardiac murmurs, must be borne in mind. The cardiac murmurs are adventitious sounds; they are never merely abnormal modifications of the heart sounds, but they are new sounds added to or replacing these.

Considering the heart sounds as two in number, these follow in a certain rhythmical order, and, in health, this suffices for the recognition of each. The sounds follow each other after an interval which is just appreciable, this interval being the short pause of the heart. After the occurrence of both an interval is readily appreciable, called the long pause of the heart. It is not necessary to carry in the memory the exact relative duration of each of the two sounds and each of the two intervals. It is sufficiently exact to say that, with the ear or stethoscope applied over the situation of the apex beat, the first sound is longer than the second, louder, lower in pitch, and has a quality which may be called booming. *Per contra,*

the second sound is shorter, weaker, higher in pitch, and has a quality which may be called valvular or clicking. Aside from the relative length, the other characters are more or less marked in different healthy persons.

A third heart sound is heard at the apex in about 65 per cent. of people under forty when they are placed in the recumbent left lateral positions (*vide* Thayer, *Arch. Int. Med.*, 1909, vol. iv, No. 4). This heart sound which is softer and of lower pitch than the second sound, occurs early in diastole and follows the second sound of the heart by about one-tenth to two-tenths second. This sound seems to be due to the sudden tension of the auriculoventricular valves, as a result of the first rush of blood from auricle into ventricle, in diastole. It is known as the proto-diastolic third sound to distinguish it from the so-called presystolic third which is sometimes heard at the time of auricular systole (*vide* Fig. 22, p. 297).

These distinctive characters of the first and second heart sounds are apparent when the ear or stethoscope is applied over the apex. At the base of the heart, that is, in the second intercostal space near the sternum, the characters of the first sound are not the same as over the apex. The second sound in this situation is louder than the first. Moreover, the first at the base may not be longer than the second; it loses more or less of its booming quality, the pitch remaining lower than that of the second sound. Removing the ear or the stethoscope a certain dis-

tance from the apex in any direction, occasions similar changes in the character of the first sound. The interposition of several thicknesses of a napkin has the same effect.

From the differential characters over the apex, and the rhythm alone in other situations, there is no difficulty in distinguishing the first from the second sound in health. In cases of disease, however, owing to disturbance of the rhythm, modifications of the characters of the first sound, and the absence sometimes of one of the sounds, other means of recognition must be resorted to. If the apex beat can be felt, this offers a ready way—the sound which is synchronous with the apex beat is, of course, the first sound. This mode is not always available, inasmuch as the apex beat cannot always be felt. Another mode is always available—namely, feeling the carotid pulse. *The carotid pulse is synchronous with the first sound,* whereas there is a slight interval between this sound and the radial pulse, so that the latter is an unreliable guide.

The Production of the Heart Sounds.—The second sound is produced by the sudden tension on the aortic and pulmonic valve segments as they close behind the blood which has just been forced into the arteries. This closure is caused by a retrograde movement of the blood in the aorta and pulmonary artery, directly the ventricular systole is ended. The retrograde movement is due to the recoil of the coats of the arteries which have been dilated by the column of

blood moving onward during the ventricular systole. This recoil causes sudden tension on the aortic and pulmonic segments which produces a sound, just as that produced by suddenly stretching a piece of cloth held slack between the hands.

The mechanism of the first sound is less simple. This sound is in part due to the forcible tension of the auriculoventricular valves, caused by the systole of the ventricles. In this way is produced a valvular element of the systolic sound. The contraction of the heart muscle itself contributes the more important part of this heart sound in health. To this element of contracting muscle the first sound is indebted for its greater intensity, its length, and its booming quality. The valvular element of the first sound is weaker than the second sound, partly because the vibrations have to be transmitted farther before reaching our ears, and partly because the tension on the auriculoventricular valves is not as sudden as in the case of the semilunars.

The Second Sounds in Health.—With reference to important bearing on auscultation in disease, the second sound is to be studied as produced at the aortic and the pulmonic orifices separately. Recalling the anatomical relations of the aorta and the pulmonary artery to the wall of the chest, if the stethoscope be applied in the second intercostal space on the right side close to the sternum, the characters of the diastolic sound are derived chiefly from the aortic valve, and if the stethoscope be applied in the second intercostal

space on the left side close to the sternum, the characters of the diastolic sound are derived chiefly from the pulmonic valve. The correctness of this statement is proved by differences in the characters of the sound

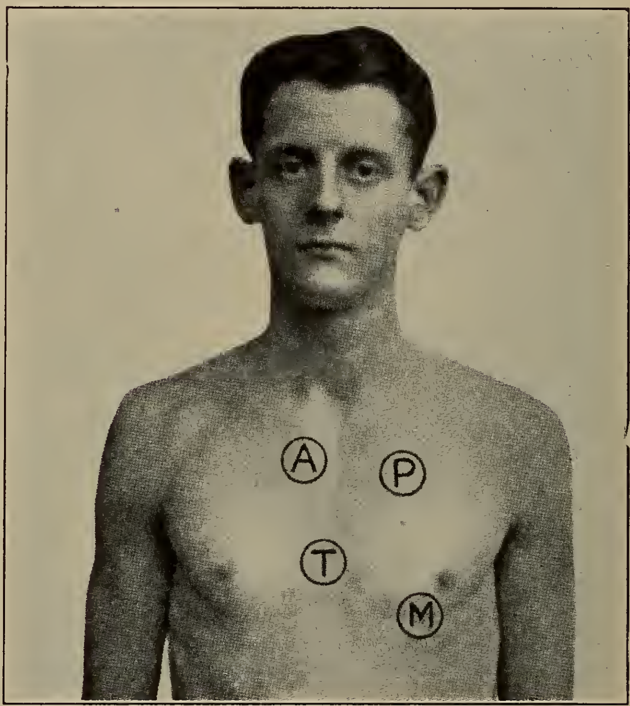


Fig. 18.—Showing the areas in which the various heart sounds are best heard in health. *A* is the area for the aortic valve; *P*, that for the pulmonary valve; *T*, for the tricuspid valve; and *M*, for the mitral valve. The pulmonary circle is a little high. (Hare.)

on two sides in health, and by the modification in cases of disease. In health the aortic diastolic sound is somewhat louder, higher in pitch, and the valvular

quality more marked than the pulmonic diastolic sound.

In patients under twenty years of age the pulmonary second sound may be found to be equal to, or louder than, the aortic second sound. Over the age of twenty, and usually to an increasing degree with advancing years, the aortic second sound is louder than the pulmonary second sound, owing, in all probability, in the main, to the increasing tension or blood-pressure in the systemic arteries at maturity and after.

The student should verify these points of difference by the study of the second sound in the pulmonic and aortic areas. In order for the comparison to be a fair one in health, and available in the diagnosis of disease, the normal anatomical relations to the wall of the chest, of the aorta, and pulmonary artery must be preserved. These relations are affected by changes in the symmetry of the chest, and sometimes by enlargement of the heart. The lungs must also be free from disease; otherwise the location of the heart or the transmission of the sounds may be abnormal.

In the account of the mechanism of the production of the heart sounds (*vide* p. 262) it was stated that the first sound consists of a valvular element and an element of muscular contraction. This valvular element is a twofold sound, that is, it is a combination of a sound produced by the mitral and a sound produced by the tricuspid valve. These

two synchronous valvular sounds may be studied separately in health, and their abnormal modifications constitute diagnostic signs in cases of disease. The two valvular sounds may be designated the mitral and the tricuspid sounds.

The second sound of the heart, as has been seen, is resolvable into two distinct sounds. Hence the number of distinct heart sounds is, in reality, four, two of which are diastolic and two systolic—namely, the mitral, the tricuspid, the aortic, and the pulmonic. Each of these four sounds may be studied separately in health and disease. The abnormal modifications of each furnish important information in diagnosis.

In health the sound of muscular contraction combined with the mitral valvular sound is heard in the region of the apex beat.

The tricuspid valvular sound is heard best at the end of the sternum or just to the left of this point.

In the pages which follow I shall sometimes refer to the first and the second sound in the singular number, it being understood that the first sound embraces two, and the second two, components; and at other times I shall refer to the sounds separately, which are combined in the two sounds.

The order of the succession of the movements of the auricles and of the ventricles is to be kept in mind (*vide* diagram, p. 297). Points of special importance are the contraction of the auricles in the latter part of the long pause of the heart, preceding the ventricular systole, and the twisting of the heart from left

to right in the systole, this movement being reversed in the diastole. In these systolic and diastolic twisting movements the visceral and parietal portions of the pericardium move upon each other, in health noiselessly, owing to their smoothness and moisture.

The movements occasion an auscultatory sign—namely, a friction murmur—when the surfaces are roughened by the presence of fibrin. Other points are the size of the pericardial sac, that is, its capability of holding when filled, but not dilated, from 15 to 20 ounces of liquid, and its attachment, not to the base of the heart, but to the vessels above the base.

PHYSICAL CONDITIONS OF THE HEART IN DISEASE.

The physical conditions of the heart in disease, which are determinable by physical exploration, are: (1) Enlargement of the heart; (2) abnormalities in position or force of the apex beat (those of rhythm and rate being considered later, p. 283); (3) valvular lesions; (4) roughness of the pericardial surfaces; and (5) liquid within the pericardial sac. Having considered these conditions, an account of abnormal modifications of the heart sounds and cardiac murmurs will conclude this chapter.

Enlargement of the Heart.—Enlargement of the heart may be slight, moderate, great, or very great. In cases of very great enlargement, the space within the chest which the heart occupies may be from four

to five times larger than in health. The situation of the base of the heart remains but little, or not at all, changed in cases of enlargement; the increased space which the heart occupies is therefore downward and laterally. The increased space extends much more to the left than to the right; the left border of the heart, in proportion to the enlargement, is carried beyond the *midclavicular* line on the left side, whereas the right border is carried comparatively but little beyond the normal right lateral boundary of the precordia even when the enlargement is very great.

The cardiac dulness may be increased in all directions or only in one direction. We naturally attribute a dislocation of the left border of cardiac dulness to the left, to enlargement of the left ventricle; a dislocation of the right border to the right, to enlargement of the right ventricle and right auricle; an increase upward, to dilatation of the left auricle or of the great vessels. In dilatation of the right auricle and ventricle in tricuspid insufficiency the cardiac dulness may extend, in third and fourth spaces, as far to the right as it is found normally to the left of the sternum.

The superficial cardiac space is enlarged in proportion to the enlargement of the heart; the organ pushes to the left the receding anterior border of the upper lobe of the left lung, and is proportionately in contact, uncovered of lung, with the wall of the chest. The apex of the heart is lowered in proportion to the enlargement of the left ventricle, and it is carried more or less to the left of its normal situation. It

may be lowered to the sixth, seventh, eighth, or ninth intercostal space. The enlargement of the heart is rarely equal in all its parts. The ventricular enlargement may be entirely, or chiefly, of either the right or the left ventricle. Enlargement of the right ventricle tends to carry the right side of the heart more to the right than when the left ventricle is enlarged. The situation of the apex is also affected by the parts of the heart in which the enlargement predominates. *The apex is carried farther to the left of its normal situation, other things being equal, when the enlargement predominates on the right side of the heart; and it is lowered, without being carried far to the left, when the enlargement of the left ventricle predominates.* The apex of the organ, in cases of considerable, or of great enlargement, becomes changed in form; it is rounded or blunted. This change is most marked when enlargement of the right ventricle predominates.

Enlargement of the heart may be due, entirely *either to hypertrophy or to dilatation* (simple hypertrophy and simple dilatation). If, however, the enlargement be sufficient to occasion notable disturbance of the circulation, both these forms of enlargement are combined, but, as a rule, one or the other form predominating; so that, of the cases of diseases of the heart which come under medical treatment, the majority are cases of either enlargement with predominant hypertrophy, or enlargement with predominant dilatation.

These widely different physical conditions are concerned especially in the abnormal impulses and modifications of the apex beat as well as, also, the heart sounds.

Abnormal Impulses of the Heart, and Modifications of the Apex Beat.—The abnormal situation of the apex of the heart when enlarged has been stated. Generally the situation is determinable by the apex beat. It has been seen that in health the beat is sometimes not appreciable by the touch, owing to the thickness of the soft parts, and the conformation of the thorax, and, for these reasons, the force of the beat varies much in different healthy persons. Exclusive of normal variations, *the beat is generally strong and prolonged, in proportion as the heart is enlarged by hypertrophy.* There are exceptions to this statement, which are to be explained by the altered form of the apex; when it loses its pointed form it does not so readily come into contact with the walls of the chest in an intercostal space, and hence the beat may be weak, although the ventricular systole be abnormally strong. On the other hand, *the apex beat is weakened by dilatation,* and it may be wanting, as a result of diminished strength of the systole of the ventricles. The apex beat is also abnormally weak in fatty degeneration and softening of the heart, as well as in functional debility of the organ, incident to other diseases than those of the heart.

If there be considerable or great enlargement, the heart being in contact with the wall of the chest over

a larger area than in health, impulses other than the apex beat are generally apparent to the eye and touch. Not infrequently impulses are appreciable in each intercostal space between the situation of the apex and the base of the heart. These abnormal impulses are felt to be strong in proportion as the enlargement is due to hypertrophy, and weak in proportion as dilatation predominates. Enlargement seated in the right ventricle causes an impulse in the epigastrium which is strong or weak in proportion as hypertrophy or dilatation predominates.

Cardiac impulses are felt and seen in abnormal situations when the heart is removed from its normal situation by the pressure of an aneurism, or other tumor, by pleuritic effusion, hydroperitoneum, etc. The error of mistaking for a cardiac impulse the pulsation of an aneurismal tumor is to be avoided. Another error is to be avoided—namely, mistaking abnormal impulses due to the heart being uncovered of lung, by shrinking of the latter in certain pulmonary affections, for impulses denoting enlargement of the heart. In cases of enlargements by hypertrophy, a heaving movement of the whole precordia is sometimes felt when the hand is applied to the chest. A violent shock is sometimes felt by the hand applied to the precordia, but without a sense of increased muscular power, in cases of purely functional disorders of the heart. Because of pericardial adhesions, or due to enlargement and displacement of the heart, a systolic retraction may be seen where

we should expect a systolic impulse, and a diastolic impulse or retraction may appear, and demand close attention to be located with reference to its place in the cardiac cycle.

Valvular Lesions.—The lesions affecting the valves of the heart may be distributed into three groups, as follows: (1) Lesions which diminish more or less the size of the orifices, or *obstructive lesions;* (2) lesions which render the valves more or less incompetent and permit regurgitation, or *regurgitative lesions;* and (3) *lesions which roughen the surfaces;* over which the blood moves without occasioning either obstruction or regurgitation. The latter may be distinguished as innocuous lesions, giving rise to no pathological effects, although represented by cardiac murmurs.

It is to be borne in mind that in the great majority of cases valvular lesions are seated in the left side of the heart, that is, they are either mitral or aortic. Tricuspid and pulmonic lesions are comparatively rare, and they are generally congenital. Not infrequently mitral and aortic lesions coexist, and there may be coexisting lesions at all the orifices of the heart.

Valvular lesions are represented by cardiac murmurs. By means of the murmurs the existence of lesions is known, their situation at the different orifices may be ascertained, and, generally, it is practicable to determine whether they occasion obstruction or regurgitation, or both. These several points of inquiry will be considered presently under the heading Cardiac Murmurs.

Roughness of the Pericardial Surfaces.—In place of the smoothness of the pericardial surfaces in health, which permits their movements upon each other noiselessly, the presence of the inflammatory product, fibrin and, in some rare instances, morbid growths, occasion an adventitious sound or murmurs, just as in the case of dry, fibrinous pleural exudates. These will be considered under Pericarditis (*vide* p. 318).

Liquid within the Pericardial Sac.—More or less liquid transudes into the pericardial sac in cases of general dropsy or anasarca, but rarely in very large quantity. Liquid effusion occurs in acute pericarditis, and in this affection the sac may become filled with serous or purulent liquid. In some cases of chronic pericarditis the sac is greatly dilated by liquid, the quantity amounting to two quarts or even more.

When the pericardial sac is filled with liquid, without being dilated, it forms a pear-shaped tumor within the chest, the base of which is at the sixth or seventh intercostal space; the apex rises nearly to the sternal notch; the left lateral border is considerably beyond the nipple, and the right lateral border is more or less beyond the right margin of the precordia. The anterior portion of the filled pericardium is mostly uncovered by lung and in contact with the wall of the chest. Within this area there is either notable dulness or flatness on percussion with an extraordinary increased sense of resistance, and absence of respiratory murmur and of vocal resonance. By means of these signs the boundaries of the pyriform

18

tumor may be readily delineated on the surface of the chest. The difference in form and situation of the area of dulness or flatness on percussion in cases of large pericardial effusion, from the area in cases of enlargement of the heart (*vide* pp. 267 and 322), is of great value in the differential diagnosis.

When the pericardial sac is partially filled with liquid, the same signs are present, but within an area of less extent, and the configuration of the pyriform tumor is wanting.

In cases of chronic pericarditis with a large accumulation of liquid, the pericardial sac is dilated so that its lateral boundaries may extend nearly to the axillary and infra-axillary regions, and the pyriform shape is usually lacking, the outline being more nearly globular. Under these circumstances flatness on percussion, absence of respiratory murmur and of vocal resonance are present over the greater part of the anterior aspect of the chest.

ABNORMAL MODIFICATIONS OF THE HEART SOUNDS.

In order to appreciate the abnormal modifications of the heart sounds, their normal characters are to be kept in mind (*vide* p. 260), and the student must be practically familiar with them. The modifications relate to the three components of the systolic sound and to the two components of the diastolic sound, collectively and separately.

The muscular element of the first sound, as heard over the apex, is intensified in hypertrophy of the heart. This sound is not only notably loud, but prolonged, and its booming quality is marked. The valvular element of the sound—namely, the mitral and the tricuspid—are also more or less increased in intensity.

In some cases of violent palpitation the valvular components of the first sound are intensified, although the muscular element is comparatively weak. I suppose the explanation to be as follows: The ventricles contract with a kind of spasmodic action upon a small quantity of blood. Under such circumstances, instead of meeting with resistance from the beginning of systole, the contraction of the ventricle is unimpeded until its cavity has decreased to the volume of the unusually small amount of blood present. At that point the sudden resistance causes an extremely abrupt rise of pressure and tension on the auriculo-ventricular valve. The resultant shock is analogous to that experienced by one who walks down an unexpected step. Hence the valvular sounds are intensified, while the sound of muscular contraction may be feeble or wanting.

The muscular element over the apex is weakened or lost, as an effect of those affections of the heart, which diminish the power of the ventricular systole. These affections are enlargement from dilatation, atrophy, fatty degeneration, myocarditis, obstruction of the coronary arteries, and softening. The systolic

valvular elements are also more or less weakened, but in a less degree than the sound of impulsion. The loss of the sound of contraction over the apex renders the so-called first or systolic sound of the heart short and valvular in quality.

Liquid effusion within the pericardium renders the sound of impulsion over the apex more or less weak. If the liquid effusion be large, only the valvular elements—namely, the mitral and tricuspid—are appreciable. Diminished power of the heart's action from other than cardiac diseases involves weakness of all the heart sounds, but more especially of those of lower pitch.

Abnormal modifications of the second sound relate to the aortic and pulmonic sounds considered separately. Whenever, from mitral obstructive or regurgitant lesions, or both combined, or from obstruction at the aortic orifice, the quantity of blood propelled by the left ventricle into the aorta is diminished, the recoil of the arterial coats, after the ventricular systole, is lessened; consequently, the aortic segments expand with less force, and the aortic sound is weakened. Diminished intensity of the aortic sound here represents a decreased arterial pressure due to abnormal diminution of the quantity of blood propelled into the systemic arteries by the systole of the left ventricle, and this diminished intensity of sound is, in a measure, a criterion of the amount of mitral obstruction or mitral regurgitation, or both combined, or of aortic obstruction. In some

cases of great regurgitation, with or without simultaneous obstruction, the aortic sound is completely suppressed. This is not dependent on blood-pressure so much as on the fact that distortion of the valves prevents their segments from coming in contact; and in proportion as they leak, they avoid the sudden tension to which normal valves are subjected.

How is weakening of this sound to be determined and measured? By comparison with the pulmonic sound. Now, as will presently appear, the pulmonic sound is often intensified when the aortic sound is weakened. Hence the former is not an accurate standard for this comparison, but it suffices for an approximation to accuracy.

In cases of hypertrophy of the left ventricle, owing to increased arterial blood-pressure, without obstruction, or regurgitant valvular lesions, the aortic sound is abnormally intensified. Intensification of the aortic sound may be due to increased tension in the systemic arteries without cardiac hypertrophy.

A simpler cause of weakening or suppression of the aortic sound is damage from lesions of the aortic valve. In proportion as the function of this valve is impaired by lesions the intensity of the sound is diminished, and if the function of the valve be lost, the sound is wanting. In these cases, the pulmonic sound being but little or not at all affected, it is an accurate standard for the comparison.

The pulmonic sound is weakened in the rare instances of lesions affecting the pulmonic valve.

This sound is oftener intensified than weakened. It is notably intensified when the right ventricle is hypertrophied, and especially when this hypertrophy is associated with dilatation of the left auricle resulting from mitral obstruction or regurgitation—the increased sound being due to a rise of pressure in the pulmonary artery.

Increased tension of the pulmonary arterial system may increase the intensity of the pulmonic sound, irrespective of hypertrophy of the right ventricle. This increased tension is due to whatever cause obstructs the pulmonary circuit, *i. e.*, whatever puts obstruction in the way of the right ventricle whether this be obstructed or regurgitated blood at the mitral orifice, paralysis of the left auricle, or mechanical obstruction of the pulmonary veins, capillaries, or arteries in the lung as the result of consolidation, fibrosis, bronchial spasm, emphysema or defective expansion of the thorax. But this increased tension in the pulmonary artery cannot be long maintained without leading to hypertrophy of the right ventricle. The pulmonary second sound is also intensified in cases of palpitation and excitation of the heart by exercise and emotion.

In comparing the aortic and the pulmonic sound in disease, as in health, it is to be assumed that the anatomical relations of the aortic and the pulmonary artery to the second intercostal space on either side, close to the sternum, are not materially altered, and that the lungs are free from lesions, in consequence

of which the conduction of the sound on either side is abnormal.

Returning to the first sounds, the mitral and the tricuspid sound may be studied separately. With the stethoscope applied at or a little to the left of the apex, the valvular element of the sound which is heard, is derived from the mitral valve, while at, or to the left of, the end of the sternum, the valvular element comes from the tricuspid. Notable weakness or suppression of the mitral sound, as compared with the tricuspid, represents impairment of the function of the mitral valve, and, *per contra*, notable weakness, or suppression of the tricuspid sound, denotes impairment of the function of the tricuspid valve. Allowance, in this comparison, is to be made for a normal disparity, the mitral sound being louder than the tricuspid in health; and for a considerable normal variation.

Reduplication of Heart Sounds.—The sounds of the heart are said to be reduplicated, when either the first or the second sounds are repeated, or when both occur twice, before the long pause or interval. Considering the heart sounds as twofold, and as represented by the whispered words Lub-dup, reduplication of the first sound is expressed by Lublub-dup; of the second by Lub-dupdup, and of both by Lublub-dupdup.

Clinically, reduplication of the second sound is observed much more frequently than reduplication of the first. In other words, the pulmonic and aortic sounds, instead of being synchronous, occur in suc-

cession. This may occur when the systolic sounds occur synchronously. The explanation is, that from increased tension of either the systemic or the pulmonic arteries (oftener the latter), the recoil of the arterial coats after the systole, and the extension of the sigmoid valves take place in one artery sooner than in the other. If both the first and the second sounds be reduplicated, the explanation which seems most rational is that the two ventricles contract, not in exact unison, but that one contracts a little before the other.

There is a form of functional disorder which may be confounded with reduplication of both sounds of the heart. In this disorder, with every alternate revolution of the heart, the sounds are weak, and the ventricular systole is not represented by a radial pulse, the force of the contraction of the ventricle being insufficient to cause an appreciable pulsation in the remote arteries; hence the heart sounds occur twice for each pulse at the wrist. Under these circumstances, however, the carotid pulse may generally, if not always, be felt with the weak as well as with the stronger ventricular contraction, and in this way the error of confounding the disorder with reduplication may be avoided. The type of arrhythmia here described is now known to be due to extrasystole, *i. e.*, the ventricles of the heart alone participate in an extra contraction, which can be heard, and gives a palpable pulse wave or not, according to the strength of the contraction (*vide* p. 286).

Reduplication of the heart sounds may occur in connection with cardiac lesions, or there may be no evidence of any organic affection. In the latter case the anomaly falls properly among the varied forms of functional disorder of the heart. Whether, or not, it be connected with lesions, it has no important pathological significance. It is usually of temporary duration.

Reduplication is to be distinguished from the presence of a third sound, either (1) the protodiastolic third often heard normally in certain positions (*vide* p. 261), and of considerable value in the diagnosis of mitral obstruction (*vide* p. 332); or (2) the presystolic third sound of auricular contraction not infrequently met in cases of cardiorenal disease.

THE PULSE.

An examination of the arterial pulse is an essential in every examination of a patient. We note its occurrence at various parts of the body, in the temporals, carotids, brachials, radials, femorals, popliteals, and in the dorsalis pedis. We observe its comparative qualities on the two sides of the body. We pay particular attention to the following characteristics: (1) Frequency (the number of beats per minute); (2) regularity (both as regards the size of individual beats and also their rhythm); (3) size (small or large); (4) celerity (the quickness or abruptness with which the individual pulse waves rise and

fall); (5) tension (the pressure within the artery); and at the same time we determine (6) the character of the arterial wall.

Frequency.—We note the frequency of the pulse in the minute, observing variations from the physiological limits, according to the age of the patient. An infrequent pulse may follow great bodily exertion, convalescence from severe diseases, malnutrition, in vomiting, during vagus stimulation, in cerebral compression, in jaundice, and in aortic stenosis alone among the valvular defects of the heart.

If the auricles of the heart beat two, three, or more times as often as the ventricles (heart-block), we note the lack of relation by combined auscultation and palpation; or by observing the auricular venous pulse in the neck, while palpating the carotid, or radial artery, or the apex beat. A particularly slow pulse may occur during the physiological effect of digitalis.

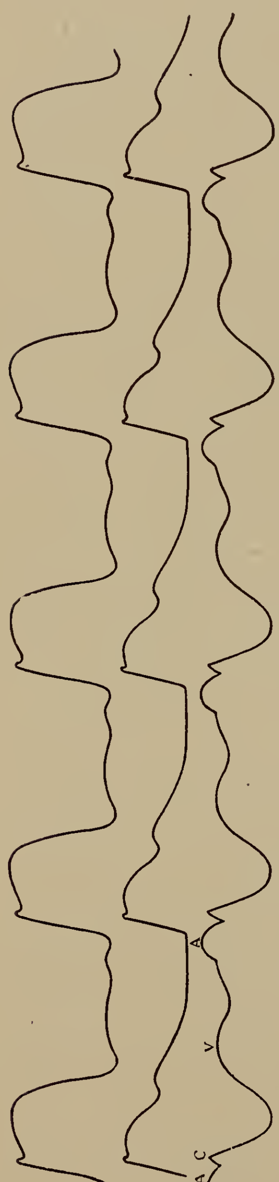
If the pulse be markedly irregular, its frequency may be decidedly less than the frequency of the ventricular contractions. In this case auscultation of the heart sounds, or palpation of the apex beat, should always be combined with palpation of the radial pulse. The difference between the ventricular rate and the radial pulse rate is spoken of as the *pulse deficit.* Followed from day to day, the record of the pulse deficit gives valuable evidence of the effect of treatment in improving the efficiency of the ventricles.

A frequent pulse may be due to muscular activity, exhausting diseases, and debilitated states. It is almost always found in fever, in vagus paralysis, in the last stage of cerebral pressure or basilar meningitis, in neurotic and toxic states, and in exophthalmic goitre, and as an important sign of weak heart muscle, in almost all cardiac, valvular defects when compensation is failing and where there is vasomotor paresis, or collapse. Excessive frequency occurring in attacks may be observed at intervals for years, usually without apparent cause (paroxysmal tachycardia).

Regularity.—We note the regularity of the pulse, as affecting its force and frequency.

The *irregularities of the pulse* are as follows:

1. Complete loss of the dominant rhythm, the intervals being wholly irregular, and the beats unequal. This is called *the completely irregular pulse,* and is usually characterized by excessive frequency as well. In cases of mild degree detection clinically may be aided by subjecting the patient to mild exercise, as the irregularity is increased with the frequency. It indicates complete failure of the normal auricular contractions, the auricles being in the state called fibrillation. The jugular venous pulse is always systolic in time. This type of irregularity may persist for years, but always denotes serious damage to the heart muscle. Among the valvular defects it is most commonly found with mitral obstruction.



Normal venous pulse compared with carotid pulse and apex beat.

Ventricular type of venous pulse (tricuspid regurgitation).

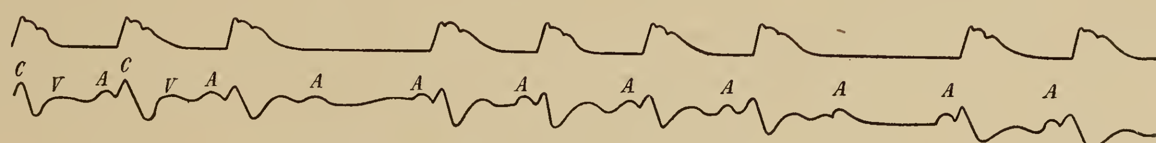
A ventricular premature beat followed by compensatory pause.

Pulsus bigeminus (coupled rhythm) due to regular premature beats.

Pulsus alternans.

Sinus arrhythmia.

Complete arrhythmia (auricular fibrillation).



Partial heart-block (carotid above, jugular below).

Fig. 19.—Diagram of normal and ventricular type of venous pulse, and cardiac arryhthmias.

2. Occasional interruption of a regular pulse by premature heart beats, usually single, rarely in groups. Such premature heart beats are called *extrasystoles.* They may occur at long intervals, or as often as every other beat. When the latter, the rhythm is called *bigeminy,* or coupled rhythm, a condition characteristic of the early toxic effect of digitalis. Extrasystoles of ventricular origin are characterized by a compensatory pause after the premature contraction—the pause being so long that the succeeding normal beat regains the previous rhythm. After auricular extrasystoles an incomplete compensatory pause follows, while extra contractions originating at the sinus have no compensatory pause at all. The more premature the contraction, the smaller the pulse wave. Very early extrasystoles fail entirely to open the semilunar valves. This type of arrhythmia is rare when the pulse rate is increased to 100 to 120, and therefore exercise makes the rhythm regular in contrast to its effect in fibrillation. Extrasystoles are not in themselves of serious significance. Occasional extrasystoles are common toxic results of tobacco, coffee, and other poisons. They occur in severe fatigue, in persons with high blood-pressure, and without evident cause.

3. Occasional complete omission of a heart beat, the true *intermittent pulse.* If the first heart sound is also absent, this indicates a temporary heart-block, and is seen also during the use of digitalis. If there is a first heart sound, but no radial pulse, it

indicates an extrasystole which was not of sufficient force to open the aortic valve.

4. Occasional sudden change occurs from a normal rhythm to a regular rhythm of usually between 160 and 200 per minute, the rapid rhythm being maintained for a few beats, for hours or even days, and usually returning abruptly to the previous normal rate. This is true *paroxysmal tachycardia*. The new rhythm is unaffected by exertion, rest, or position. Abruptness of onset and of return to normal are particularly characteristic.

5. Closely allied to paroxysmal tachycardia and but recently differentiated from it is *auricular flutter*. In this form of tachyrhythmia the electrocardiograph has shown that abnormal impulses are occurring in the auricle at between 200 and 500 per minute. The ventricle cannot follow such excessive rapidity, and a heart-block is almost invariably present. The most common finding is an auricular rate of 320 per minute with heart-block of 2 to 1, so that the ventricular rate (and arterial pulse) is 160. The change from normal rhythm to auricular flutter is not abrupt, as in paroxysmal tachycardia, but is separated by a period of auricular fibrillation. "If tachycardia persists for a month or more and is not changed in rate by change of posture, rest or exercise, the case is almost surely one of flutter." (Mackenzie.)

6. Moderate variation in the rate of the dominant rhythm, synchronous with respiration, is normal in children and in many adults. This is called the

respiratory irregularity, or *sinus arrhythmia,* as it depends upon the varying rate of discharge of impulses from the sinus node, the normal pace-maker of the heart. Similar variation in the dominant rhythm occurs in excitement, and may be marked in meningitis. It is due to stimuli received by the heart through the vagus nerves, and never signifies disease of the heart muscle. Exertion decreases or stops the irregularity.

7. Alternation of large and small beats, without noticeable variation in the intervals which separate them, constitutes the *alternating pulse.* It is to be carefully distinguished from bigeminy, that variety of extrasystolic arrhythmia in which every second beat is premature. In both conditions small and large beats alternate, but in pulsus bigeminus the small beat comes in ahead of its proper time and is followed by a compensatory pause. In pulsus alternans irregularity of size alone occurs. The prognosis is much more grave, for the condition is due to serious impairment of the contractile power of the heart muscle.

Inspiration may cause decrease in the size even to obliteration, and frequency of the pulse, in cases of inflammations and tumors of the mediastinum (*pulsus paradoxus*).

Size.—The pulse is large or small, according to relation between the amount of blood delivered to the great vessels during systole, and the emptiness of the vessels at the end of diastole. We find a large

pulse often in hypertrophy of the left ventricles, expecially in aortic regurgitation, and often in the sthenic stage of fevers. We find the pulse small in syncopal attacks, in cardiac muscular weakness, in stenosis of any cardiac valvular orifice, particularly in mitral and aortic stenosis, and during chills.

Inequality of size and force upon the two sides is sometimes present as a result of abnormalities of the size of the arteries upon one side, or from pressure as by an aneurism of the aorta.

Quickness.—We note the rapidity with which the pulse fills and empties (or the celerity). We find a quick pulse in the collapsible pulse of aortic insufficiency (the water-hammer or Corrigan pulse), and where we have a relaxed arterial wall at the same time that the heart is overacting, as in the asthenic stage of fevers. We have a slow pulse in aortic stenosis, and where we have high peripheral resistance and no disturbance of the reflex nervous control of the heart.

Tension.—We note the sense of resistance or tension of the pulse as appreciated by applying the tips of three fingers to the artery, and noting the pressure needed at the proximal finger to prevent the appreciation of the pulse by the distal finger. Although we may get a general impression of the tension by palpation, very great errors are so frequently made that palpation estimations of blood-pressure are today unjustifiable as a basis for diagnosis or treatment.

19

A hard pulse is with difficulty obliterated by digital pressure. Nephritis of the chronic type and advanced arteriosclerosis usually exhibit a hard pulse.

A soft or easily compressible pulse is found in fever, anemia, weakness of the heart muscle, and in vasomotor paresis.

Character of Arterial Wall.—We note the character of the arterial wall, *i. e.*, whether the arterial wall is palpable or not, when the pulse is obliterated by pressure farther up the arm. The normal radial artery is not palpable when empty. A firmly contracted artery is to be distinguished from an artery with an hypertrophy of its muscular wall, and both of these conditions from a smooth fibrous replacement in the wall, or, what is easier, from the so-called pipe-stem artery with nodular calcareous deposits. These are appreciated by rolling the vessel under the finger-tips, or the edge of the nails.

Capillary Pulsation.—The capillaries may show systolic pulsation in cases where the arterial pulse is very large. It is therefore seen particularly in aortic insufficiency, though also in some cases of low blood-pressure from decreased tone in the end arteries, as in exophthalmic goitre or neurasthenia. The capillary pulse may be seen as a faint pulsation if a microscope slide be pressed against the mucocutaneous margin of the lower lip, just hard enough to blanch the skin, or if the end of the nail is bent, to the point of blanching the pulp beneath, or in the systolic flushing of a line drawn across the forehead by the finger.

Pulsation of the Cervical Veins.—A pulsation in the external jugular veins for about three-quarters to an inch above the clavicle is normally visible in the majority of people when lying down. It depends upon the pressure changes in the right auricle, the pulsation being transmitted up the column of blood within the veins and through the intervening valves. In the erect posture gravity and the normal negative pressure within the thorax keep these veins so empty that transmission of such weak pulsations is usually impossible. On the other hand, if the veins be constantly distended, the pulsation is too weak to cause appreciable increase in their size, and no pulsation is seen, as can be demonstrated by tilting the patient's head sufficiently downward. In cases of emphysema, therefore, where the negative pressure of the thorax is much decreased, venous distention may obliterate the normal pulsation when horizontal, although it is present in the upright position, especially when the intrathoracic negative pressure is increased during inspiration.

The pulsation in the veins is visible, but very rarely appreciable by the touch. It is to be distinguished from pulsation of the arteries of the neck. This is easily done by finding that pressure just above the clavicle, sufficient to interrupt the flow of blood in the veins but not in the arteries, abolishes the pulsation. Careful inspection shows the venous pulsation to be, not a single wave, but a flickering which may be resolved into three component waves, named A, C, and V respectively. The wave A corresponds to the contraction of the right

auricle, C to the closure of the tricuspid valves, and V to filling up of the right auricle during ventricular systole (*vide* Fig. 19, p. 284).

The most significant feature of the venous pulse is its change in character in tricuspid insufficiency. When this occurs the right auricle receives blood both from the veins and also from the right ventricle during ventricular systole. As a result the V wave increases in size and begins earlier, even to a point where it completely obliterates the C and the A waves. In marked tricuspid regurgitation, instead of the usual A–C–V flicker, we find a large, slow, heaving pulsation synchronous with the carotid (*vide* Fig. 19, p. 284).

CARDIAC MURMURS.

All adventitious abnormal sounds which are added to the heart sounds are embraced by the term cardiac murmurs. Let it be borne in mind that the murmurs are never abnormal modifications of the heart sounds, but always newly produced sounds, and they always represent morbid conditions of either the heart or the blood. When due to morbid conditions of the blood they are called inorganic, anemic, or hemic murmurs, and when they represent valvular lesions or changes within the heart they are distinguished as organic murmurs.

In fevers, as of the acute infectious diseases, or in high temperature from various other causes, we commonly find a systolic murmur at the apex correspond-

ing to the murmur of mitral regurgitation. This may be heard also in marked anemia and in extreme asthenia, and this murmur may properly be called a functional murmur, as it seems to be due to an atonic or relaxed condition of the mitral ring, and to a lack of proper functioning of the papillary muscles.

A systolic murmur heard over the base of the heart, especially at the second left interspace, seems to be due to a dilatation of the conus arteriosus, and is found to occur not infrequently in fever and anemias, and from unexplained causes.

In healthy adults there is, not uncommonly, during expiration, a systolic murmur heard over the base of the heart, and disappearing during inspiration. This is usually more easily heard in those with flat chests. It is rather common in children. The important distinguishing point about this murmur is its dependence upon the expiratory phase of respiration. Its causation is not well understood.

There are other accidental murmurs, usually systolic, but occurring also in any part of the cardiac cycle, of which the cause is uncertain and the importance negligible.

The murmurs may be distributed into three groups after differences in quality, namely: (1) soft; (2) rough; and (3) musical murmurs. The soft murmurs resemble the sound produced by air from the nozzle of a pair of bellows, and, hence, are often called bellows murmurs. Murmurs are said to be rough when their qualities may be expressed by such terms as rasping,

rumbling, croaking, etc. They are called musical when the sound is a musical note. The bellows murmurs are the most frequent, and the musical are more rare than the rough murmurs. The quality of a murmur has not in general any special pathological or diagnostic significance. The murmurs vary in pitch, being either relatively high or low. The variations in pitch are useful in aiding to discriminate different coexisting murmurs.

This account of murmurs applies to those produced at the orifices or within the cavities of the heart. They are distinguished as endocardial murmurs. Adventitious sounds are, however, produced upon the external surface of the heart. These constitute pericardial, or friction murmurs.

Endocardial murmurs are produced by blood-currents pursuing either a normal or an abnormal direction. With a familiar knowledge of these currents, and of their relations with the heart sounds, the several endocardial murmurs are very easily understood.

Directing the attention to the left side of the heart, there are two normal blood currents—namely, the current from the left auricle to the left ventricle, and the current from the left ventricle into the aorta. These may be distinguished as the direct currents. The first is the mitral direct current, and the second is the aortic direct current.

Two abnormal currents may occur in the left side of the heart. These currents can only take place when the valves are rendered incompetent by lesions. The

incompetency of the valves allows of regurgitation, and these abnormal currents may be distinguished as the regurgitant currents. One of these is a current backward from the left ventricle into the left auricle, owing to incompetency of the mitral valve; this is the mitral regurgitant current. The other is a current backward from the aorta into the left ventricle, arising from incompetency of the aortic valve; this is the aortic regurgitant current.

What are the relations of the four currents in the left side of the heart with the heart sounds. The *mitral direct current* takes place when the mitral valve opens after ventricular systole, and continues open up to the closure of the valve at the following systole. In other words, blood flows through the mitral valve throughout ventricular diastole—that is, from the time of the second sound up to the following first sound—and *murmurs due to obstruction of the mitral valve can only occur at some period of ventricular diastole.* This period covers the time of rest of the whole heart (diastole), and also the period of auricular contraction (spoken of clinically as presystole).

The *mitral regurgitant current* is caused by the contraction of the ventricle; the current, therefore, must take place during ventricular systole, that is, beginning with the first sound and lasting practically up to the second.

The *aortic direct current,* being caused by the contraction of the left ventricle, takes place during systole. It is therefore coincident with the mitral regurgitant current.

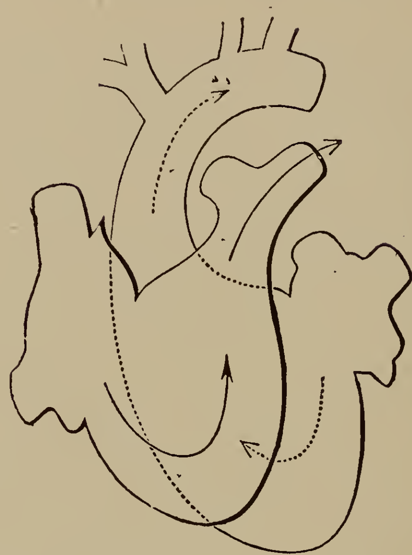


Fig. 20.—Diagram representing the normal blood currents. Plain arrows represent currents in right side of heart. Dotted arrows represent currents in left side of heart.

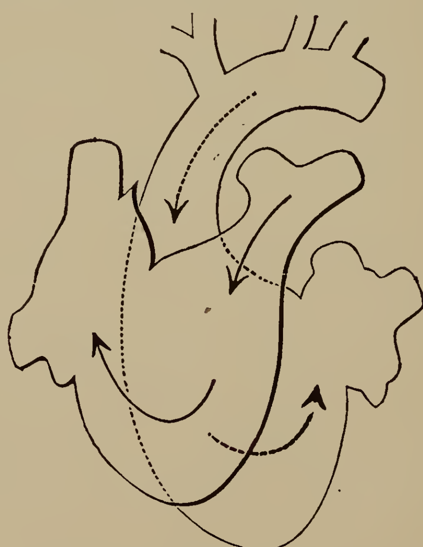
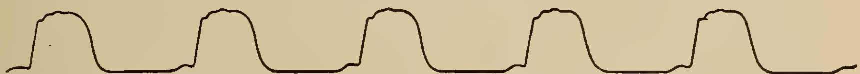


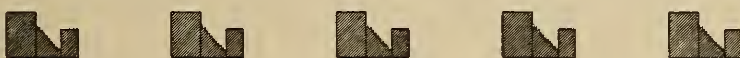
Fig. 21.—Diagram representing the abnormal blood currents. Plain arrows represent currents in right side of heart. Dotted arrows represent currents in left side of heart.

Carotid pulse.



Apex impulse, showing a small wave due to auricular contraction preceding the ventricular.

Normal heart sounds; and (in dotted lines) the points at which presystolic and protodiastolic third sounds may be heard.



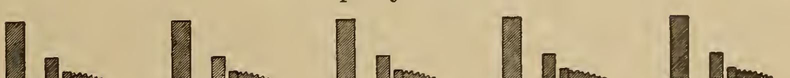
Systolic murmur as in insufficiency of auricular ventricular valves or stenosis of semilunar valves.

Diastolic diminuendo murmur of aortic insufficiency.

Mitral stenosis with short intense S1 (snapping first sound) and presystolic crescendo rumble (moderate narrowing with a strong auricle).

Mitral stenosis, severe grade; rumble throughout diastole with presystolic accentuation.

Mitral stenosis with auricular fibrillation, diastolic murmur, no presystolic.



Mitral stenosis with distinct protodiastolic third sound with which an early diastolic rumble starts.

FIG. 22.—Diagram of time relations of auricular and ventricular systole (shown on apex impulse) to carotid pulse, heart sounds, and murmurs.

The *aortic regurgitant current* is caused by the recoil of the arterial coats upon the column of blood within the aorta, directly after the ventricular systole; and as this recoil causes the aortic second sound of the heart, the current and this sound must start together, unless the second aortic sound is wholly replaced by the sound of the regurgitant current. The leakage backward through an incompetant aortic valve begins with the second sound and continues up to the following ventricular systole.

Recapitulating the relations of the four currents with the heart sounds, the aortic direct and the mitral regurgitant are systolic currents. The mitral direct current and the aortic regurgitant current takes place during ventricular diastole.

Analogous blood currents take place in the right side of the heart, and have corresponding relations with the heart sounds. These currents are the tricuspid direct, the tricuspid regurgitant, the pulmonic direct, and the pulmonic regurgitant. The pulmonic regurgitant is rare in consequence of the infrequency of pulmonic lesions; but the tricuspid regurgitant is not uncommon, and occurs without valvular lesions or enlargement of the heart when the right ventricle is distended with blood, constituting what has been called the "safety valve function" of the tricuspid orifice.

Organic endocardial murmurs are produced by the foregoing direct and regurgitant blood currents, and they are designated by the same names, that is,

they are either direct or regurgitant murmurs. Thus there are produced in the left side of the heart—the side in which valvular lesions are seated in the great majority of cases—a mitral direct murmur, a mitral regurgitant murmur, an aortic direct murmur, and an aortic regurgitant murmur. In the right side of the heart there may be produced corresponding murmurs—namely, a tricuspid direct, a tricuspid regurgitant, a pulmonic direct, and a pulmonic regurgitant.

Mitral Direct Murmur.—This murmur is due to vibrations of the mitral direct current flowing through the mitral valve. Vibrations of moderate degree are normally present and can be heard, as Thayer has shown, with a stethoscope applied directly to the left ventricle. They are not normally, except in rare instances, of sufficient intensity to reach the chest wall. Narrowing of the valve (mitral stenosis) increases the velocity of flow and therefore the vibrations, which then become audible at the chest wall.

With a *severely obstructed mitral valve and a strong right heart,* the velocity of flow may be sufficiently maintained to produce a murmur throughout the whole period of ventricular relaxation. The murmur then begins with the second sound and continues to the following first sound, filling the period of rest of the whole heart and also that of auricular systole (presystole). It is sometimes called diastolic-presystolic in time.

Such murmurs, though not infrequent, are less common than those heard only in a portion of the period

of ventricular diastole. The velocity of flow through an obstructed mitral valve is greatest when the pressure in the auricle is highest, in comparison to that in the ventricle. If the auricle were paralyzed, obviously it would be most distended just at the end of ventricular systole, for during that period blood has been steadily pouring into the auricle from the pulmonary veins. In such a case we would expect the velocity of flow, and consequently the murmur, if present, to be most marked at the beginning of ventricular relaxation and to decrease as the ventricle became filled; and this we find to be the case in just those cases *where the auricle has ceased its coördinate contractions (auricular fibrillation), provided the right heart continues to maintain a reasonable pressure in the pulmonic vessels. The murmur occurs in early and mid-diastole.*

Where the left auricle is not paralyzed, however, its contraction accelerates the flow of blood at each auricular systole, intensifying the vibrations at that period; so that the murmur is particularly audible at this (presystolic) time. On the other hand, a strong left auricle that has emptied itself in systole, has room in diastole to accommodate the inflow from the pulmonary veins without being subjected to great distention. Ventricular diastole, therefore, finds the blood within the auricle under less pressure than in the case of the paralyzed auricle, so that there is less cause for a murmur in early diastole. *In the cases of moderate and well-compensated mitral stenosis, therefore, the murmurs are most frequently present at the time of auricular systole—that is, they are usually presystolic.*

Almost invariably this murmur is rough in quality; occasionally it is a soft bellows murmur. When rough it is often quite loud. The rough quality is peculiar; it is suggestive of vibration, and may be imitated by causing the lips or the tongue to vibrate with the breath in expiration. It is caused by the vibrations of the mitral curtains, and takes place when these curtains are united at their sides, leaving a narrow buttonhole-like orifice through which the mitral direct current of blood flows. Throwing the lips into vibration with the breath, represents not only the characteristic quality of the murmur, but the mode of its production. The physical conditions which are requisite generally for its production are a narrowed mitral orifice, and enough pressure within the auricle to force the blood through the obstruction at sufficient velocity. The latter condition is not always present so that *a murmur, previously plain, may disappear with the onset of severe decompensation.*

This murmur may be produced artificially, and the mechanism of its production demonstrated in the following manner: Take a small India-rubber bag with thin walls—such as that which, when inflated, makes a balloon for children; attach the opening to the efferent tube of a Davidson syringe; make a small orifice opposite to the attached opening of the bag; immerse the bag in a basin of water, and then force a current of water into the bag. With a binaural stethoscope, the pectoral extremity applied lightly to the bag, a murmur caused by the flow of water from the bag into

the basin is heard, resembling as closely as possible the usual presystolic murmur.

A mitral direct murmur is never due to a morbid condition of the blood. Although it occurs without mitral lesions (*vide* Flint murmur, p. 303), yet, inasmuch as its occurrence then requires the existence of aortic regurgitant lesions, it cannot be said to be an inorganic murmur. A mitral direct murmur may occur in adherent pericardium (chronic fibrous pericarditis), and in large hearts without valvular lesions; in the latter the accessory signs of mitral stenosis are lacking.

A mitral direct murmur, as has been stated, does not always accompany mitral lesions. If the mitral curtains are fixed or made rigid by calcification, so that vibration with the mitral direct current of blood does not take place, either the murmur may be wanting, or its usual characteristic quality may be absent. Feebleness of the auricular contraction, from dilatation or overdistention of the auricle with blood, may cause the murmur to disappear from presystole. Under these circumstances the murmur may be sometimes present and at other times absent. *Cardiac vibration or thrill* is a physical sign which accompanies often a well-marked characteristic presystolic murmur, but this sign may occur in connection with other valvular lesions. The thrill is presystolic or diastolic-presystolic in time.

It is apparent, then, that in mitral stenosis, owing to the differences in the size of the opening, the flexibility of the cusps, the volume of blood and the force of the auricular contraction, we may have an absence

of any murmur, or most commonly a presystolic murmur, or less often a murmur which may occupy any point of time between the systolic sound and the diastolic sound of the heart, *i. e.*, a diastolic, or meso-diastolic, or diastolic-presystolic murmur.

The Flint Murmur.—A mitral direct murmur may be produced without mitral lesions, the murmur having the same characteristic quality as when lesions exist, and being also quite loud. This fact, based on clinical proof, was stated by me many years since, together with the explanation. *The murmur occurs when there are aortic lesions which permit regurgitation.* Under these circumstances, at the time when the auricular contraction takes place, the left ventricle is already filled with blood, the mitral curtains are floated out so as to be in contact with each other, the anterior curtain being also pushed shut by the stream of regurgitating aortic blood which strikes its anterior surface (*vide* Fig. 23, p. 304). The mitral direct current passing between the curtains throws them into vibration precisely as when the orifice is narrowed. The vibration of the lips when lightly in contact, caused by the expired breath, illustrates the manner in which a mitral direct murmur takes place without mitral lesions. The murmur thus occurring without mitral lesions is more variable from day to day than is the murmur of mitral stenosis; it is now present and now absent. It follows from what has just been stated that a mitral direct murmur is not always a sign of mitral obstructive lesions when there is free aortic regurgitation. (This

murmur is commonly recognized in the United States as the Flint murmur.)

Fig. 23.—Frontal section of the thorax, showing ascending and descending vena cava; left ventricle and the close relation of aortic valve to the anterior curtain of the mitral valve. From this specimen the x-ray, Fig. 16, p. 258, was taken. (Norris and Fetterolf.)

This murmur is limited to a circumscribed space around the apex of the heart. However loud the murmur may be in this situation, it is usually lost within a short distance of the apex, although in rare instances it may be heard over the lower part of the left scapula.[1]

Mitral Regurgitant Murmur—Mitral Systolic Murmurs of Cardiorespiratory and Functional Origin.—The mitral regurgitant murmur, synchronous with and following the systolic sounds, that is, a systolic murmur may be soft, rough, or musical in quality, its intensity and pitch being variable. Aside from its relation with the first or systolic heart sounds, it is distinguished by having its maximum of intensity at or near the situation of the apex beat. It may be limited to a circumscribed area, and if heard at a distance from the apex it is best transmitted laterally round the left side of the chest, on the line of the apex. This is of particular significance in diagnosis because the systolic murmurs originating at other valves may sometimes be heard even as far as the apex, but practically never beyond it. It is often heard on the posterior aspect of the chest near the lower angle of the left scapula, and not infrequently in the corresponding situation on the right side.

The impulse of the apex of the heart against the adjacent portion of the lung sometimes forces the air from the air vesicles sufficiently to give rise to a blow-

[1] For further diagnostic and explanatory details of the Flint murmur the reader is referred to an article by Thayer in Amer. Jour. Med. Sci., 1901, cxxii, No. 6.

ing sound occurring with each ventricular systole. This is liable to be confounded with an endocardial murmur. Produced in the way just stated, it is heard only during

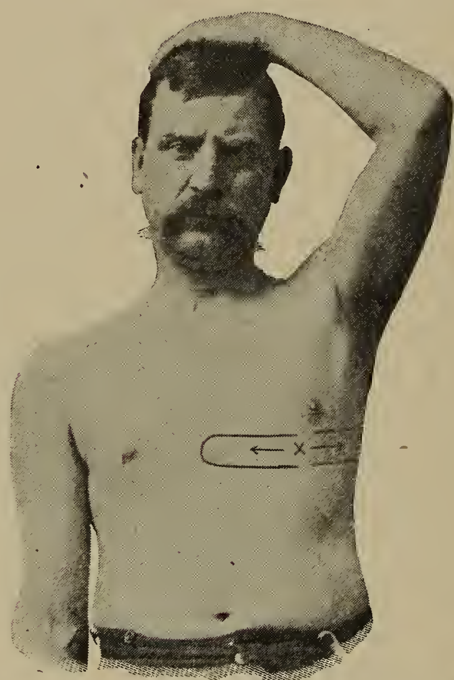


FIG. 24.—Showing at *X* apex beat where the murmurs of mitral regurgitation and mitral obstruction can be best heard. The arrow pointing outward indicates the direction in which the regurgitant murmur is transmitted, and the arrow pointing to the sternum shows the area in which murmurs of mitral stenosis may occasionally be transmitted. (Hare.)

the act of inspiration, and especially at the end of this act. Such murmurs are known as cardiorespiratory.

A purely *functional incompetency of the mitral valve occurs,* permitting a mitral regurgitant current, no

actual lesion of the valve or the mitral orifice existing. This functional regurgitation depends upon decreased tone of the muscular fibers of the mitral ring allowing dilatation of the opening, and upon impaired action of the papillary muscles. In this way are explained the occurrence of a mitral systolic murmur and its disappearance without other evidence of endocarditis or any organic affection of the heart.

That a mitral systolic murmur may exist, continue for weeks or months, and even for years, and disappear, the murmur being neither accompanied nor followed by signs or symptoms denoting organic disease, is an important fact to be borne in mind with reference to diagnosis and prognosis. It is apparent from experimental studies as well as from clinical observation that a true mitral regurgitation, with the characteristic murmur so constantly associated when the valve cusps are diseased, may occur from any of several causes which permit of a relaxation of the constrictor ring of muscle which encircles the mitral orifice. Among the causes frequently recognized are high temperature, acute endocarditis, with or without coexisting chorea, and any cause, either general (anemia) or local (myocarditis), which may interfere with the muscular competence of the mitral ring. Strain of the heart muscle is apt to be a determining factor. Mitral incompetence from such lack of muscular efficiency is much more commonly accompanied by tricuspid incompetence than when the mitral leak is due to disease of the cusps themselves.

Aortic Direct Murmur.—This murmur, like the mitral systolic murmur, occurs with and following the systolic sound of the heart. Of the organic murmurs on the left side of the heart, the mitral systolic murmur and

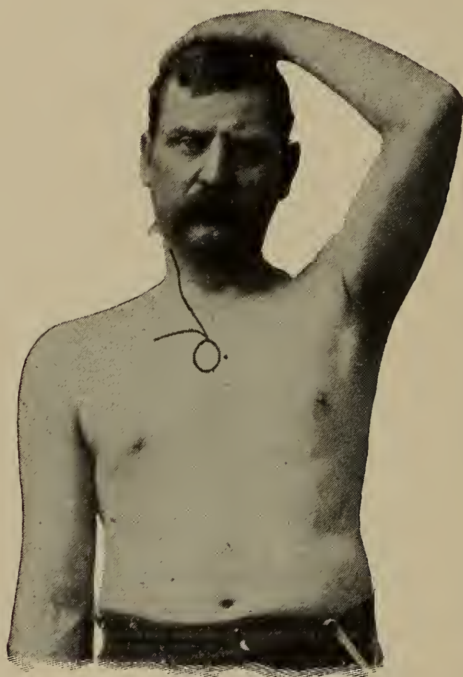


Fig. 25.—Showing the area of greatest intensity and the direction of transmission into subclavian and carotid arteries of the aortic obstructive murmur. (Hare.)

the aortic direct murmur are synchronous, the others having different relations with the heart sounds. The aortic direct murmur differs from the mitral systolic murmur in having its maximum of intensity at the base of the heart. It is loudest in the second

intercostal space near the sternum. As a rule it is louder in this intercostal space on the right than on the left side; this rule, however, has frequent exceptions. It is transmitted better and farther upward than downward. It is always heard over the carotid artery, and it is sometimes louder over this artery than at the base of the heart. As a murmur may be produced within the carotid artery, it is desirable to determine, when a systolic murmur is heard at the base, whether the carotid murmur is a transmitted murmur or not. This point is to be settled by comparing the murmur over the carotid with the murmur at the base, as regards quality and pitch. If the quality and pitch of the murmur in the two situations be the same, it is fair to consider the murmur in the carotid as not produced within the artery, but conducted by the blood current from the aortic orifice.

An aortic direct murmur is frequently inorganic. It is to be considered as such when it is not associated with an aortic regurgitant murmur, cardiac enlargement or evidence of previous syphilitic infection; and when anemia is shown by the presence of murmurs in the large arteries, and the venous hum[1] in the neck—these

[1] To obtain the venous hum (*bruit de diable*), cause the patient to turn the head as far as practicable to the left, and apply the stethoscope to the neck on the right side, near the clavicle, behind the sternocleidomastoid muscle. Press the stethoscope with different degrees of force before concluding that the murmur is wanting. The venous hum is continuous, and closely resembles the sound of the humming top. Gentle pressure, with the finger

physical evidences of anemia being associated generally, not invariably, with pallor, and with symptoms pointing to impoverishment of the blood. Moreover, an inorganic murmur is very rarely rough, and it is variable in its occurrence, being at one time present and at another time absent, whereas, an organic murmur is, in general, constant. Associated with other evidence of anemia, an aortic direct murmur may, nevertheless, be organic; but, under the differentiating circumstances just stated, the lesion represented by the murmur, if the murmur be organic, must be innocuous, so that it is not of great practical importance to determine whether the murmur be or be not inorganic.

Like the other organic murmurs, an aortic direct murmur varies in different cases in intensity, quality, and pitch. An organic aortic direct murmur *per se* does not by any means always denote aortic obstruction (*vide* p. 333). It may be due simply to roughness of the membrane at or above the aortic orifice, or to dilatation of the aorta. Such evidence as these, whether attributed to roughness or to dilatation, are recognized

above the stethoscope, so as to interrupt the flow of blood in the veins, causes the murmur at once to cease. This fact is proof of its being a venous murmur. A systolic murmur heard with the stethoscope applied to the neck is an arterial murmur which may either be produced within the artery or transmitted from the aortic orifice. An arterial and a venous murmur in the neck often coexist. One cause of error in determining the presence of a true venous hum is the common occurrence of a murmur in the vessels of the thyroid gland.

as proof of inflammation of the aorta, almost without exception of syphilitic origin.

Aortic Regurgitant Murmur — Aortic Diastolic Non-regurgitant Murmur, or a Prediastolic Murmur.—An aortic regurgitant murmur occurs with, and following,

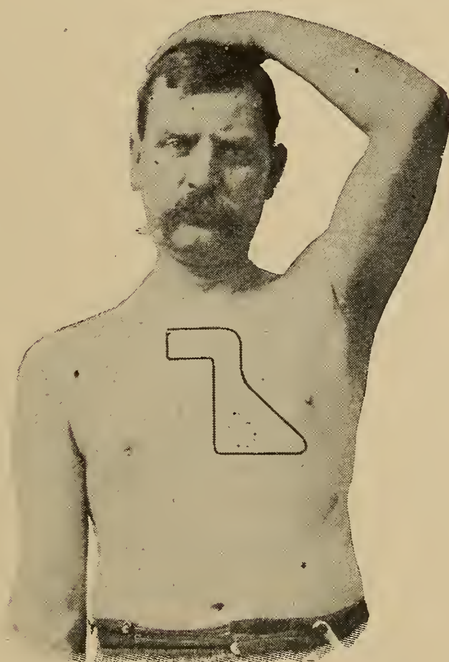


FIG. 26.—Showing the area in which the murmur of aortic regurgitation can be most clearly heard. The left nipple is raised by the position of the arm. (Hare.)

the second sound of the heart. It is almost always heard at the base of the heart, but, in some instances, when not appreciable at the base, it is heard a little below the base—namely, near the sternum on the left side on a level with the fourth costal cartilage. In

some instances, however, the maximum of intensity is in a corresponding situation on the right side. It is transmitted best in a downward direction, being often heard at the apex, and sometimes considerably outside or external to this point (*i. e.*, in the left axilla). It is never inorganic. It is usually not intense, low in pitch, and soft; but it may be loud, high, rough, or musical.

The aortic diastolic murmur is sometimes heard with the ear when it is inaudible with the usual small-bell stethoscope.

A short murmur is sometimes produced by the retrograde movement of the blood current within the aorta, the aortic valve being intact, and regurgitation, therefore, not taking place. This murmur is due to roughening of the lining membrane of the aorta by atheroma or calcareous deposit, and it is always preceded by an aortic direct murmur. It occurs directly after the systole, and ends with the second sound. Although of such brief duration, it is distinctly recognizable and distinguished from the preceding aortic direct murmur. I have long been accustomed to demonstrate this murmur in private teaching, and have called it an aortic diastolic non-regurgitant murmur. A better name is a prediastolic murmur. It cannot be said to have much practical importance, inasmuch as the lesion giving rise to it is represented by the aortic direct murmur which precedes it. This murmur may be associated with a true regurgitant murmur. This is the explanation

of a diastolic murmur which is rough before and soft after the aortic second sound.

Coexisting Endocardial Murmurs.—The murmurs referable to the left side of the heart, which have been considered, are often found in combination; two or three may coexist, or all of them may be present. Moreover, with more or less of these murmurs may be associated murmurs referable to the right side of the heart. The mitral murmurs are not infrequently associated. The mitral direct, being diastolic, ends with the systolic sounds, and the mitral systolic or regurgitant begins with these sounds; the systolic sounds, as it were, divide these two murmurs. These murmurs almost invariably differ from each other in pitch and quality. The presence of both, in fact, assists, rather than obstructs, the recognition of each. The aortic direct and the aortic regurgitant murmur, also, are often associated. A murmur then accompanies the systole and diastole of the heart; the two murmurs follow in the same rhythmical order as the groups of heart sounds. These murmurs, when associated, can only be confounded with pericardial friction sounds.

The combination of the aortic direct and the mitral systolic murmur alone offers any difficulty. These two murmurs have the same relation with the heart sounds; they are both systolic. How is it to be determined, when a systolic murmur is heard both at the base and apex, whether a mitral murmur is transmitted to the base, or an aortic murmur is transmitted to the apex; in other words, whether two murmurs are

present or only one murmur? If these two murmurs coexist, generally the circumstances which distinguish each separately can be ascertained. Thus, the aortic murmur is transmitted into the carotid artery, and the presence of that murmur is then established; the mitral regurgitant murmur is often transmitted laterally around the chest, or heard at the lower angle of the scapula, and then the presence of that murmur is established. But there are additional points, namely, the murmur at the base and that at the apex generally differ sufficiently in pitch or quality to render it evident that there are two murmurs; and generally at a situation in the precordia between the base and apex both murmurs may be either lost or become notably weakened. Attention to these points in most instances divests the problem of difficulty.

Mitral and aortic lesions are often of a character to give rise to only one murmur at either of these orifices. A mitral direct murmur is occasionally present without the mitral regurgitant, and the reverse of this is often found. So, either an aortic direct or an aortic regurgitant murmur may exist without the other.

Tricuspid Direct Murmur.—The lesions which are requisite for this murmur very rarely occur at the tricuspid orifice; hence this murmur is exceedingly rare. It is to be distinguished from the mitral direct murmur by its localization, being, not at the apex, but at the right border of the heart. Mitral direct murmur is usually found to coexist with a tricuspid

direct murmur, in which case a presystolic murmur, with the characteristic blubbering quality is heard at the apex and at the right side of the heart.

Tricuspid Regurgitant Murmur.—This murmur is not of infrequent occurrence. Tricuspid regurgitation occurs often when the right ventricle is considerably dilated, without the existence of lesions of the valve. Tricuspid regurgitation, however, does not invariably give rise to an appreciable murmur. When a ventricular venous pulse is found in the neck, or better still, if a systolic liver pulse is found, these help materially to establish a diagnosis of tricuspid regurgitation when taken with the other signs.

The tricuspid regurgitant murmur, of course, occurs with the first or systolic sound, being systolic like the mitral regurgitant murmur; and the latter generally coexists. It is distinguished from the mitral regurgitant by its localization at the right inferior margin of the heart, and its transmission to the right, rather than to the left. The coexistence of the mitral and the tricuspid regurgitant murmurs is determined by the differences in pitch and quality between a systolic murmur at the apex and at the right margin of the heart. A venous pulse, synchronous with the first sound of the heart, and a systolic pulsation of the liver are far better signs of tricuspid insufficiency than is the presence or absence of a systolic murmur at the tricuspid area.

Pulmonic Direct Murmur.—A pulmonic direct murmur, if organic, is generally connected with con-

genital lesions. The pulmonic direct and the aortic direct current of blood taking place at the same instant, the murmurs representing both are systolic. How is the pulmonic to be distinguished from the aortic direct murmur? The pulmonic murmur is heard in the left second intercostal space close to the sternum, but this is not very distinctive, inasmuch as, not infrequently, the aortic murmur is loudest in that situation. The essential point of distinction is this: *the pulmonic direct murmur is not transmitted into the carotid artery,* whereas the aortic direct murmur is always thus transmitted. A systolic thrill, appreciated by firm palpation in the second left interspace, is an important and fairly constant sign in pulmonary stenosis. If an aortic direct and a pulmonic direct murmur coexist, the combination is to be ascertained by finding that the murmur in the second intercostal space on the right side differs from that on the left side in pitch or quality.

An inorganic or functional pulmonic direct murmur is of frequent occurrence in cases of anemia. It is frequently associated with an inorganic aortic direct murmur, the presence of the two murmurs being evidenced by a difference in pitch.

Pulmonic Regurgitant Murmur.—This murmur is exceedingly rare in consequence of the infrequency of pulmonic regurgitant lesions. It occurs, of course, like the aortic regurgitant, with the second or diastolic sound. Its presence can be determined when other signs go to show the existence of pulmonic and the

absence of aortic lesions. This murmur may, however, occur without any lesion or deformity of the pulmonary valve cusps or of its orifice under conditions similar to those which may determine an aortic regurgitant murmur—namely, *increased blood-pressure in the pulmonary artery, due to marked obstruction in the pulmonary vessels, sufficient to cause a dilatation of the pulmonary orifice,* and lack of apposition of the semilunar cusps. This so-called murmur of high pressure in the pulmonary artery is commonly known as the Graham-Steell murmur. A pulmonic regurgitant murmur may occur from pressure upon the pulmonary artery from without.

Facts of practical importance in relation to the endocardial murmurs are embraced in the following statements:

The question as to a murmur being organic or inorganic relates chiefly, if nor entirely, to the aortic direct, the pulmonic direct, and the mitral regurgitant murmur, other murmurs being almost invariably organic.

Associated signs and symptoms (*vide* Valvular Lesions) generally warrant a definite conclusion whether an aortic direct or pulmonic direct murmur be, or be not, organic, and under the circumstances which render it difficult to decide this question positively, a positive decision is not of much immediate practical consequence.

Valvular lesions, whether obstructive, regurgitant, or innocuous, are so uniformly represented by murmur, in a compensating heart that, as a rule, absence of

lesions may be predicated on the absence of murmur. If, however, the signs and symptoms of a decompensating heart are present, no conclusions should be drawn from the presence or absence of murmurs as to the existence or location of valvular lesions.

With a practical knowledge of the different organic murmurs the situation of lesions at either of the orifices of the heart, or their existence at two or more of these orifices, may be demonstratively determined.

By means of the murmurs, with other signs, it may be determined demonstratively whether the lesions involve obstruction or regurgitation, or both, or, on the other hand, that they are, as regards immediate pathological effects, innocuous.

The *murmurs do not afford definite information as to the amount of obstruction or regurgitation;* in other words, as to the pathological importance or gravity of lesions when they are not innocuous. No positive conclusions on this point of view are to be drawn from the intensity of murmurs, their pitch, or their quality. As a rule murmurs which are weak, more than those which are loud, represent grave lesions.

Pericardial Friction.—A pericardial or friction murmur is produced by the rubbing together of the surfaces of the pericardium in the systolic and diastolic movements of the heart. In the vast majority of the cases in which this murmur occurs it denotes either the presence of recent fibrin which renders the surfaces more or less adhesive, or roughening from fibrin which

has become dense and adherent; its diagnostic significance, therefore, relates almost exclusively to pericarditis. In this relation it is of great practical importance.

This extracardial murmur is to be discriminated from the endocardial murmurs. The points involved in the discrimination are as follows. The murmur is usually double, accompanying both ventricular systole and diastole. It can, therefore, only be confounded with an aortic direct and an aortic regurgitant murmur in combination. At the base it is not infrequent to hear also friction during auricular systole, and in these cases the 1–2–3, shuffleboard, murmur is extremely characteristic. The quality of the murmur is suggestive of rubbing or friction. It is sometimes a feeble, grazing sound; in other instances it is loud and rough. When rough, the quality is expressed by such terms as rasping, grating, creaking, etc. Although accompanying both the systolic and diastolic sounds of the heart, it has not that uniform, fixed relation to these sounds which characterizes the aortic direct and the aortic regurgitant murmur. It is not in definite accord with the heart sounds. Moreover, in intensity it varies with the successive movements of the heart, being louder with some revolutions than with others. In this regard it differs notably from the endocardial murmurs. It is not heard without the precordia, as a rule, and is often limited to a part of the precordial region; whereas certain of the endocardial murmurs —namely, the mitral regurgitant and the aortic direct—

are often heard at a considerable distance from the heart. Firm pressure with the stethoscope, and often a forced expiration, intensify the murmur. Its source seems very near the surface of the chest. In this respect it differs notably from endocardial murmurs, the latter appearing to come from a certain distance within the chest. This point of distinction is very appreciable, especially if, as often happens, a friction murmur be associated with an endocardial murmur. The pleuropericardial friction occurring in acute fibrinous pleurisy adjacent to the heart may produce friction sounds identical with those of true pericarditis. Therefore in dry pleurisy of the left anterior chest the diagnosis of a simultaneous fibrinous pericarditis is difficult.

CHAPTER IX.

THE PHYSICAL DIAGNOSIS OF DISEASES OF THE HEART AND OF THORACIC ANEURISM.

Enlargement of the heart by hypertrophy and dilatation—Valvular lesions, mitral, aortic, tricuspid, and pulmonic—Diseases of the heart muscle—Endocarditis—Pericarditis—Functional disorders—Congenital defect—Thoracic aneurism.

THE morbid physical conditions incident to the different diseases of the heart and the corresponding signs have been considered in the preceding chapter. The diseases are now to be considered with reference to the assemblage of signs on which the physical diagnosis of each is to be based. Most of the diseases of the heart may be diagnosed by means of physical signs. A few cardiac lesions do not admit of a physical diagnosis, and they do not, therefore, claim consideration in this work. The following are the affections which will form separate headings in this chapter: Enlargement of the heart by hypertrophy and by dilatation, valvular lesions, diseases of the heart muscle, endocarditis, pericarditis, functional disorders, congenital defects, and the diagnosis of thoracic aneurism.

Enlargement of the Heart by Hypertrophy and by Dilatation.—Physical exploration to determine the size of the heart has three objects—namely, to determine (1) that the size of the heart is normal, or (2) that the heart is enlarged, and (3) the degree of enlargement. These objects are attainable by means of percussion and auscultation, with considerable accuracy, but for truly precise delimitation of the heart the orthodiagraphic method with the *x*-ray is preferable.

The heart is of normal size when the apex beat is in its normal situation, that is, in the fifth intercostal space, a little within the midclavicular line. When the superficial cardiac space is not enlarged, as shown by percussion and by auscultation of the voice (*vide* p. 254), and when percussion shows the lateral borders of the heart to be situated normally—namely, on the left side a little within the line of the nipple, and on the right side a finger's breadth to the right of the right margin of the sternum—these points of evidence warrant a positive conclusion that the heart is not enlarged, if the lung borders overlapping the heart are normal.

The fact of an enlargement, and its degree, are determinable by an abnormal situation of the apex, together with an increase of the superficial cardiac space, and extension of the lateral boundaries of the deep cardiac space, especially on the left side.

In cases of slight or *very moderate enlargement, the apex is situated a little without the midclavicular*

line, but not below the fifth intercostal space. A somewhat greater enlargement lowers the apex to the sixth intercostal space, and removes it farther without the midclavicular line. In greater degrees of enlargement the apex is lowered to the seventh, eighth, or ninth intercostal space, and generally farther removed to the left.

The lowering of the apex and the removal to the left are not uniformly proportionate to each other. As a rule, if the right side of the heart be chiefly enlarged, the apex is removed without the midclavicular line farther than when the enlargement of the left side of the heart predominates; and when the latter is the case, the apex is lowered out of proportion to its removal without that line. The relatively abnormal situation downward or to the left, thus, is evidence of the enlargement predominating in either the left or the right side of the heart.

Generally the situation of the apex is apparent to the touch, and frequently to the eye. In some instances, however, the impulse can neither be seen nor felt. How is its situation to be then ascertained? Auscultation furnishes a ready and reliable mode of determining this point. The situation in which the first sound of the heart has its maximum of intensity corresponds to the situation of the apex. This is hardly less definite than the presence of an appreciable impulse.

In determining the fact of enlargement and its degree by the abnormal situation of the apex, we *must exclude mere lateral displacement* of the heart

from extracardiac causes. The apex is removed to the left of its normal situation by enlargement of the left lobe of the liver, abdominal tumors, hydroperitoneum, the pregnant uterus, and gastric tympanites. These extrinsic conditions are to be excluded or due allowance made for them. In some cases in which one or more of these extrinsic causes of displacement may exist the apex is carried into the axillary region. It is to be borne in mind that these causes of displacement may exist when there is more or less enlargement of the heart. All these causes, while they displace the apex to the left, do not lower, but tend to raise it above its normal situation. On the other hand, an aneurismal or other tumor, situated above the heart, may press downward the organ, or an unusually long first portion of the arch of the aorta may occur, and in this way the apex is more or less lowered.

The *superficial space is increased* in proportion as the heart is enlarged. The extent of this increase is easily determined by percussion and auscultation. Within this space there is notable dulness on percussion. The degree of dulness is greater than within the superficial cardiac space in health, and this degree of dulness is proportionate to the greater area in which the heart is uncovered of lung. It is easy to delineate by percussion on the chest the boundary of the anterior border of the upper lobe of the left lung; in other words, of the oblique line which is the hypotenuse of the right-angled triangle,

representing the superficial cardiac space in health and in disease. The area of the superficial cardiac space is also not less readily and precisely ascertained by auscultation of the voice; the limits of the lung within the precordia are denoted by an abrupt cessation or notable diminution of the vocal resonance. In women with large mammæ auscultation is more available for this object than percussion. The extent to which the superficial cardiac space is enlarged is a good criterion of the degree of the enlargement of the heart.

In proportion as the heart is enlarged, *the situation of the left border of cardiac dulness is without the mid-clavicular line.* Its situation is determined by percussion. Dulness, although not great, is sufficiently distinct within the deep cardiac space, and the line which denotes the left border of the heart is easily delineated on the chest. This statement holds true with respect to the right border of the heart. But this border, even when the enlargement of the heart is great, is removed comparatively little to the right of its normal situation, except in dilatation of the right auricle and right ventricle in tricuspid regurgitation. Then it is not unusual to find the superficial cardiac dulness as much as three fingers' breadth to the right of the sternum in the third and fourth interspaces. By means of percussion the boundaries of the precordia, as enlarged by the increased size of the heart, may be determined and measured. In making this statement it is assumed that the lungs are not

diseased, and that the chest is not deformed. Shrinkage of the upper lobe of the left lung may enlarge the superficial cardiac space, and cause displacement of the heart. The latter is an effect of the presence of pleuritic effusion, and it may follow its removal. In cases of deformity from spinal curvature, to determine the fact of enlargement of the heart or its degree is not always an easy problem.

There is a liability to *error in localizing the apex* in some cases of enlargement. Owing to the blunted form of the apex, especially when the enlargement is chiefly of the right side of the heart, the apex beat may be feeble. It is likely to be overlooked, and a stronger impulse in the intercostal space above the apex be mistaken for the apex beat. Of course the lowest impulse is the apex beat, for the apex beat is the point farthest downward and to the left at which definite impulse is palpable; it is not the point of maximum impulse (P. M. I.). Careful palpation, and finding by auscultation the spot where the first sound has its maximum of intensity, will prevent error.

Enlargement of the heart, and the degree of enlargement having been ascertained, it is to be determined whether hypertrophy or dilatation predominate. If the enlargement be slight or moderate, it may be a question whether hypertrophy or dilatation exist alone. As a rule, if either of these two forms of enlargement exist without the other, it is hypertrophy, for, with rare exceptions, hypertrophy

precedes dilatation. If the enlargement be very great, as a rule, dilatation predominates, for the capability of hypertrophic increase of size has its limit, and an increase of size beyond this limit must be due to dilatation.

The signs, denoting on the one hand hypertrophy, and on the other hand dilatation, relate to the impulses of the heart and to the heart sounds. With a moderate enlargement *hypertrophy is to be inferred from an abnormal force of the apex beat and an intensification of the systolic sound,* especially the sound of muscular contraction over the apex. With a considerable or great enlargement, if hypertrophy predominate, the apex beat may be abnormally strong and prolonged, but, as already stated, owing to its blunted form, the beat is sometimes weak and scarcely appreciable; the increased power of the ventricular contractions, representing the hypertrophy, is then to be determined by impulses in the intercostal spaces above the apex. These impulses are sometimes present in each intercostal space between the apex and the base, and they are abnormally strong in proportion as hypertrophy predominates. Still more marked evidence of hypertrophy is sometimes obtained when the hand is placed over the precordia; a powerful heaving movement is felt. The increased power of the ventricular contractions may, in some cases, be in this way appreciated somewhat as if the heart were held in the hand. In cases of considerable or great hypertrophic enlargement, the intensity of

the sound of impulsion over the apex is notably increased; it is prolonged, and its booming quality is more marked than in health. Not infrequently it is accompanied by a metallic ringing sound or tinnitus.

Moderate enlargement by *dilatation is characterized by abnormal weakness of the apex beat, and of the systolic sound over the apex.* Cases, however, of simple dilatation are rare. If the enlargement be considerable or great, the dilatation predominating, all the impulses are weak, as compared with the cases in which hypertrophy predominates; and the muscular element of the first sound over the apex is diminished or *nil;* the feeble, short, mitral valvular sound either supplanting or predominating. These points of distinction are marked in proportion as dilatation predominates.

In the great majority of the cases of enlargement of the heart, valvular lesions coexist. These coexisting valvular lesions are represented by endocardial murmurs, and they may generally be excluded by the absence of the latter. In most of the cases in which enlargement exists without valvular lesions, it is associated with either pulmonary emphysema or chronic Bright's disease.

VALVULAR LESIONS.

The physical diagnosis of valvular lesions embraces their localization at the different orifices within the

heart, and the determination of their character as giving rise to obstruction and regurgitation; or of their innocuousness in these respects. These objects of diagnosis involve the endocardial murmurs and the abnormal modifications of the heart sounds which were considered in the preceding chapter. Lesions at the different orifices—namely, the mitral, aortic, tricuspid, and pulmonic—will be considered separately.

Mitral Lesions.—The lesions at the mitral orifice are represented by the mitral murmurs—the mitral direct murmur, the mitral regurgitant, and the mitral systolic non-regurgitant or functional murmur. Mitral obstructive lesions exist whenever the mitral direct murmur is present, with an exception already stated and explained (*vide* Flint Murmur, p. 303)—namely, this murmur is present in some cases in which the mitral valve is intact; aortic lesions, giving rise to free regurgitation, existing in these cases. These exceptional instances are rare.

Mitral regurgitant lesions cannot be diagnosed on the mere presence of a systolic murmur at the apex. A *systolic murmur* having its maximum of intensity at or near the apex, *transmitted laterally* for a certain distance beyond the apex on the left side of the chest, and heard on the back near the lower angle of the scapula, generally, if not invariably, denotes a regurgitant current. The evidence is still stronger if *hypertrophy* or *dilatation* can be demonstrated, or if increased pressure in the pulmonary vessels can be

shown, by *accentuation of the pulmonic second sound.* But it cannot be overemphasized that a systolic murmur limited to a small area around the apex, or to the superficial cardiac space, is not proof of regurgitation. A truly regurgitant murmur, however, may be too feeble to be transmitted beyond the apex; the proof of regurgitation must then be based on other evidence associated with the murmur—namely, on enlargement of the heart and abnormal modifications of the heart sounds.

Mitral obstruction may occasionally exist without incompetency of the mitral valve. The converse of this is of more frequent occurrence, that is, regurgitation may frequently exist without obstruction. The absence, however, of a mitral direct murmur is not positive proof against mitral lesions, for, as has been seen (*vide* p. 301), the production of a characteristic mitral direct murmur requires the obstruction to be caused by an adherence of the mitral curtains at their sides, the curtains being sufficiently flexible to vibrate with the passage of the mitral direct current of blood, and the blood flow must be sufficiently rapid to produce the vibrations. If these conditions for the production of the murmur do not exist, there may be no murmur produced by the mitral direct current, or, if a murmur be present, it is devoid of the usual characteristic quality. Mitral obstruction and regurgitation not infrequently coexist, as shown by the presence of both the mitral direct and the mitral regurgitant murmur. A mitral murmur produced

by a mitral direct current, but diastolic in point of time, is frequently, as has been seen (*vide* p. 299), observed in connection with mitral stenosis. It is accepted now, on accurate experimental and clinical evidence, that the cause of the change in time of the mitral direct murmur, from presystolic to diastolic, is the progressive narrowing of the mitral orifice. Auricular fibrillation results in a loss of the presystolic propulsive force, which determines the incidence of the usual presystolic mitral murmur, as long as the auricle contracts effectively.

Cases of mitral stenosis in which the murmur is absent require particular attention. Absence of the murmur, as stated, is due to insufficient velocity of the blood flowing through the obstruction. In the group where low velocity is present because the obstruction is mild, active exertion is extremely useful. Extremely characteristic murmurs appear where a moment before nothing abnormal was found. But in the group where the murmur is absent, despite well-marked stenosis, because of a weak right heart, exercise is less useful and not always justifiable. Two other signs are of value—*the snapping first sound* (with the corresponding *tapping apex beat*) and *the protodiastolic third* (the "opening snap"). The former consists in an unusually sharp, snapping, valvular quality of the first sound frequent in mitral stenosis, and sometimes extremely marked. Quite commonly it can be heard a few inches away from the chest, and occasionally even from the foot of the bed.

With this type of first sound there is usually also a quick tap-like apex impulse, which is frequently equally characteristic. The cause is connected with the emptiness of the ventricle at the onset of systole, so that its contraction is unopposed until fully under way (*vide* p. 275).

A protodiastolic third heart sound may be heard in normal health (*vide* p. 261), but it is seldom of any great intensity. In mitral stenosis, however, this third heart sound is frequently very distinct. It is apparently due to the sudden tension on the edges of the mitral valve when, with ventricular diastole, it starts to open widely but cannot. It may well be compared to the opening of a door protected by a chain latch; and the name "opening snap" is well chosen. In cases where there is doubt as to the presence of a mitral obstruction—either because the characteristic murmur is absent or because, in the presence of aortic insufficiency, the question of a Flint murmur is raised—the tapping impulse, snapping first sound, and diastolic third sound are all valuable evidence in favor of a mitral stenosis.

The mitral *murmurs do not per se denote the amount of obstruction or regurgitation,* or of both combined. Information with reference to these points may be derived, in the first place, from a comparison of the aortic with the pulmonic second sound. The amount of obstruction or regurgitation, or both, is great in proportion as the aortic sound is weakened, or the pulmonary sound accentuated, or both. *Per contra,*

there can be but little obstruction or regurgitation, if the aortic and the pulmonic second sound preserve completely or nearly their normal relation to each other in respect to intensity. Information may, in the second place, be obtained by directing attention to the mitral valvular sound (*vide* p. 266). In proportion as the closure of the mitral valve is compromised by lesions, the mitral valvular sound at the apex will be weakened.

Enlargement of the right side of the heart, which results from mitral obstructive and regurgitant lesions, is a criterion of the amount of obstruction and regurgitation, taken in connection with the length of time they have existed. Hypertrophic enlargement of the right ventricle intensifies the pulmonic second sound, and allowance must be made for this modification in determining, by a comparison of the pulmonic and the aortic sound, the degree in which the latter is weakened. Attention is to be given to the tricuspid valvular sound (*vide* p. 266). The intensity of this sound is, in some measure, a criterion of the power of the right ventricular systole.

Aortic Lesions.—Lesions are localized at the aortic orifice by the aortic murmurs—namely, the aortic direct and the aortic regurgitant murmur. Aortic obstructive lesions give rise to an aortic direct murmur; but it must be considered, in the first place, that *an aortic direct murmur may be inorganic*, and, in the second place, that if the murmur be organic it *may be produced by lesions which occasion no*

obstruction, and are consequently innocuous from a mechanical stand-point. The existence of obstructive lesions must be determined by evidence added to the presence of the murmur. This evidence is either diminished intensity or suppression of the aortic second sound, enlargement of the left ventricle, a systolic thrill in the aortic area, and modification of the pulse. If the lesions which occasion obstruction are of a character to diminish or arrest the movements of the aortic valve, the aortic second sound will be either weakened or lost. If valvular lesions be limited to the aortic orifice, the degree of enlargement of the left ventricle is a criterion of their pathological importance, although the almost constant occurrence of regurgitation when aortic stenosis is present, detracts from the value of hypertrophy as evidence of the former. Excluding aneurism, a systolic thrill at the second right interspace is rarely found except in true stenosis.

The *character of the arterial pulse* is of great value. In typical cases it is small (parvus), rises slowly (tardus), is prolonged (longus), and is infrequent (rarus). In other words, it is a slow, rounded wave, in absolute contrast to the sudden high-peaked wave of aortic regurgitation. When such a pulse is present it is of the greatest diagnostic significance. But it is by no means always present, because in the vast majority of cases aortic regurgitation complicates the picture and tends to produce a pulse of totally different character. In the absence of typical thrill

and pulse, the points usually to be considered are the degree of hypertrophy compared to the size of the pulse. With a pulse but slightly water-hammer in type we probably have to do either with a very slight aortic leakage with no stenosis, or else there is a large regurgitation combined with a stenosis which neutralizes the effect of the regurgitation upon the pulse. With moderate cardiac hypertrophy the former would be probable, with great hypertrophy the latter.

Regurgitant lesions at the aortic orifice give rise to an aortic regurgitant murmur. This murmur, of course, is always proof of regurgitation; but the murmur gives no definite information concerning the amount of incompetency of the aortic valve. A loud murmur may be produced by a regurgitant stream so small as to be, for the time, insignificant; and, on the other hand, a large regurgitant current may give rise to a feeble murmur. The extent to which the valve is damaged by the lesions is to be determined, first, by either weakness or suppression of the aortic sound, and second, by the degree of enlargement of the left ventricle.

Aortic obstructive and regurgitant lesions are often associated. An aortic direct and an aortic regurgitant murmur are then both present, with a weakened aortic sound or its suppression, and enlargement of the left ventricle according to the amount of the obstruction and regurgitation, together with the length of time during which the latter have existed. These effects, and not the intensity, nor the pitch,

nor the quality of the murmurs, are indicative of their pathological importance.

Mitral and aortic lesions often coexist, giving rise to two, three, or four of the obstructive and regurgitant murmurs in the left side of the heart. In addition to the murmurs in these cases, the effects of the combined lesions are shown in the modification of the heart sounds, and the enlargement of both sides of the heart.

Tricuspid Lesions.—Tricuspid obstructive lesions are exceedingly rare. A few instances of the kind of obstruction which is represented by a tricuspid direct diastolic or presystolic murmur, have been reported. One instance has fallen under my observation. In this case, as in the other instances which have been reported, the tricuspid was associated with mitral lesions; hence, in localizing an obstructive lesion at the tricuspid orifice, the presence of the presystolic murmur on each side of the heart, that is, the coexistence of the mitral and the tricuspid direct murmur is to be determined. This point has already been considered (*vide* p. 314). Signs which are accepted as fairly characteristic of tricuspid stenosis are: a diastolic or presystolic murmur at the tricuspid area without accentuation of the second pulmonic sound; often in addition an aortic lesion; an enlarged right ventricle and auricle, distended veins in the neck, frequently without pulsations; persistent cyanosis of mucous membranes and skin, and marked tendency to edema or general anasarca with relatively little

dyspnea. The diagnosis should be made without a presystolic murmur, as this is inconstant. There is almost always coincident mitral stenosis. There is likely to be a pulsation recorded over the liver coincident with auricular contraction.

Tricuspid regurgitation is not uncommon. Generally the insufficiency is caused by dilatation of the right ventricle occurring as an effect of mitral regurgitant or obstructive lesions. Tricuspid regurgitation is not always represented by murmur; and when a tricuspid regurgitant murmur is present, it is to be discriminated from a coexisting mitral regurgitant murmur. This point has been considered (*vide* p. 315). A sign of free tricuspid regurgitation with hypertrophy of the right ventricle is pulsation of the liver, which may be seen and felt, and is synchronous with ventricular systole. This pulsation is sometimes notably strong. If the liver be enlarged, the pulsation may be communicated to the greater part of the abdomen, and its force may be suggestive of aneurism of the abdominal aorta. Pulsation of the liver may be observed when there is no ventricular jugular pulse, nor notable turgescence of the cervical veins. On the other hand, pulsation of the ventricular type in the cervical veins may be present when liver pulsation is indetectable.

Pulmonic Lesions.—As compared with aortic lesions these are of infrequent occurrence, and they are generally congenital. Lesions giving rise to a pulmonic direct murmur may be localized by differen-

tiating this murmur from the aortic direct murmur (*vide* p. 315). It is to be considered that *an inorganic pulmonic direct murmur is not infrequent.* Pulmonic regurgitant lesions can only be diagnosticated by determining that a murmur is produced at the pulmonic, and not at the aortic orifice (*vide* p. 316).

DISEASES OF THE HEART MUSCLE.

None of the diseases of the heart muscle is represented by distinctive physical signs, but, nevertheless, the physical diagnosis taking into account the clinical history, may be quite positive. The signs, as well as the symptoms, are those which denote persistent muscular weakness of the heart. The most marked evidence is notable weakness of the systolic sounds, and especially weakness or suppression of the muscular element of the first sound. In the acute degeneration of the myocardium which accompanies acute infectious fevers, enfeeblement or disappearance of the apex beat and weakness of the systolic sounds are the only signs, and the symptoms are only part and parcel of the symptoms of the underlying disease. The same is true of the brown atrophy of the heart which occurs in wasting diseases, such as tuberculosis and cancer. In the more serious changes of acute infectious myocarditis, as seen in diphtheria, acute articular rheumatism, some cases of pneumonia and influenza, and rarely in other infections, may be added the signs of dilatation of the heart, with or without a

functional mitral regurgitation. The symptoms of muscular weakness of the heart become prominent, and various disturbances of rhythm may arise from damage to areas of the heart having specialized functions.

Heart-muscle weakness is a part of the clinical picture of anemia of any severity. Here some dilatation is the rule, the apex beat is more diffuse, the impulse sudden, the sound of contraction feeble, the systolic sound valvular in quality. A systolic murmur is heard over the pulmonary artery; also, as a rule, a mitral regurgitant murmur, due to dilatation of the mitral orifice. In the more severe fatty degeneration of the heart of pernicious anemia, similar signs are found, but the enlargement is more marked, hypertrophy and dilatation being usual, and the murmurs are more pronounced. Venous hum in the neck is helpful in the diagnosis of the heart muscle weakness of anemia (*vide* p. 309).

Chronic myocarditis, as a sequel of acute myocarditis of coronary artery disease with multiple small infarctions (fibroid myocarditis), or primary, as in syphilitic myocarditis, the fatty heart, and other chronic affections of the myocardium, cannot be distinguished from one another with certainty during life. The most that can be attempted wisely is the diagnosis of chronic myocardial disease or weakness, and its discrimination from myocardial weakness secondary to chronic valvular disease, adherent pericardium, the hypertrophy of Bright's disease, emphy-

sema, and so forth. The most important physical sign is the loss of the sound of muscular contraction at the apex, the systolic sound which is heard being chiefly or exclusively the mitral valvular sound. This sound is short and valvular in quality, like the diastolic sound. The apex beat may be feeble, or diffuse and shock-like. If the heart be dilated, the apparent force of the apex beat is in contrast to the feebleness of the radial pulse. With dilatation, functional mitral, and also tricuspid, regurgitation may occur, and reach such a grade as to render the discrimination from primary mitral valvular disease difficult, if not impossible. The history of past acute articular rheumatism, or a known mitral murmur, is of special importance in making the decision. In muscular weakness a systolic murmur at the apex may be brought out only by exercise. This should always be sought for.

Various disturbances of rhythm may occur (*vide* p. 283) of which the most important are heart-block, due to a lesion involving the atrioventricular bundle, and the complete irregularity which denotes auricular fibrillation. When the latter exists, it may be difficult or impossible to distinguish primary myocardial disease from mitral obstruction after the disappearance of the mitral direct murmur (*vide* p. 301). Here, again, the history is of more value than the physician signs.

Endocarditis.—The physical diagnosis of endocarditis relates especially to its occurrence in connection

with articular rheumatism. A variety of murmurs may occur, the commonest one, and one upon which the diagnosis is often based, is a mitral systolic but not necessarily organic murmur. The presence of this murmur, however, in a case of rheumatism, is not positive proof of an existing endocarditis, more especially if the patient had previously had articular rheumatism, because an endocarditis developed in a previous attack may have left a permanent murmur. If the murmur be a mitral regurgitant murmur, and the heart be definitely hypertrophied, it is quite certain that endocarditis has occurred previously. The appearance of the murmur during an attack of rheumatism, when previous examination had shown none, particularly if accompanied by enlargement and accentuation of the pulmonic second sound, is usually indicative of endocarditis; although slight mitral leakage due to dilatation of the ring is frequently present as a result of myocardial weakness.

An aortic direct murmur, in cases of rheumatism, is not evidence of endocarditis, because in many cases of rheumatism this murmur occurs, and is to be regarded as inorganic.

In the variety of endocarditis, known as ulcerative, occurring in the course of infectious or septic diseases, and sometimes without any known point of entrance of the infecting organism, an aortic murmur may be developed, with or without a coexisting mitral murmur, owing to the soft masses present on the valves.

Acute endocarditis is probably of frequent occurrence as secondary to pre-existing mitral and aortic valvular lesions; but, under these circumstances, a physical diagnosis is impracticable unless definite change in the character and intensity of the murmur occurs, or fever, enlarged spleen, and petechial spots are present.

Pericarditis.—The physical diagnosis of pericarditis in the first stage, that is, *prior to the effusion of liquid, is to be based on a pericardial friction* murmur. Fortunately for diagnosis, this murmur is uniformly present, though at times for only a brief period. Its characters as contrasted with endocardial murmurs have been stated (*vide* p. 218). The presence of a pericardial friction murmur, in connection with symptoms denoting pericarditis, renders the diagnosis quite positive. There is, however, one liability to error. In some cases of pleurisy or pneumonia with pleuritic inflammation, the movements of the heart occasion a rubbing together of the roughened pleural surfaces, and in this way a cardiac pleural friction murmur is reproduced (pleuropericardial). This may be single or double, and when double, it simulates the murmur produced within the pericardial sac. It is limited to the border of the heart, and is neither accompanied nor followed by pericardial effusion. Of course the error of mistaking a cardiac pleural friction murmur for one produced within the pericardium can only occur when pleurisy exists, either as a primary affection or as secondary to pneumonia, or to pulmonary tuberculosis.

In the second stage of pericarditis, that is, after the effusion of liquid has taken place, the pericardial friction murmur often, but not always, disappears. The physical diagnosis in this stage is then to be based on the signs which show the presence of a greater or less quantity of liquid within the pericardial sac. The signs which denote *pericardial effusion,* and its amount have been stated (*vide* p. 273). With a moderate effusion the apex of the heart is raised, and the apex beat may be felt in the fourth intercostal space, and removed to the left of its normal situation. With considerable or large effusion the apex beat is lost, and the sounds of the heart are feeble and distant. The muscular quality of the first sound is lost, leaving the mitral and tricuspid sounds, which are short and valvular like the diastolic sounds.

Increase or diminution of liquid in the second stage of pericarditis is readily determined by signs obtained by percussion and auscultation. When the quantity is much diminished, the friction murmur, if it has been suppressed, returns, and persists until the pericardial surfaces become agglutinated. Not infrequently, by auscultating when the body of the patient is inclined forward, a friction murmur may be heard, notwithstanding the pericardial sac contains a large quantity of liquid.

In cases of chronic pericarditis with very large effusion, dilatation of the pericardial sac is shown by signs obtained by percussion and auscultation.

There is no apex impulse, the heart sounds are feeble and distant, the systolic sounds being short and valvular, and the precordia may be notably projecting. There may be systolic retraction at or near the apex beat. Dulness with soft bronchial breath sounds may be found in the left infrascapular region as a result of compression of the lung.

A malignant growth filling the pericardial sac and inclosing within it the heart may give rise to all the signs of pericardial effusion. A case of this kind, in a young subject, has fallen under my observation.

With reference to diagnosis, the etiological relations of pericarditis should be kept in mind. These are acute articular rheumatism, Bright's disease, tuberculosis, and either pleurisy or pneumonia. It rarely occurs in other connections; and, as an idiopathic affection, it is extremely rare.

The presence of air and liquid within the pericardial sac gives rise to loud splashing sounds which, occurring when respiration is suspended, and when hydropneumothorax is excluded, are at once diagnostic of hydropneumopericardium.

FUNCTIONAL DISORDERS.

Many of the so-called functional disorders of the heart are now recognized as due to distinct localized lesions of such parts of the heart and great vessels as have to do with the origination and conduction of

cardiac contractions. For a summary of these the reader is referred to the description of irregularities of the pulse on page 283.

There are other groups of symptoms, in which disorder of heart action plays an important role, which have no constant or at present recognized structural cause, and some are evidently temporary disturbances of reflex cardiac nervous mechanism.

We may consider here angina pectoris, exophthalmic goitre, and palpitation.

By angina pectoris we mean an attack, or recurring attacks, of severe substernal pain, which is apt to radiate into the arms, and especially to the left arm, and is accompanied by a sense of impending death. In the majority of cases this is found to be due to obliterative diseases of the coronary arteries, and more particularly the orifices of these arteries at their origins in the aorta, this being often merely a part of a general or extensive aortitis.

Examination of the heart during or between attacks may reveal nothing abnormal. It is upon the history and symptoms of the case, and not upon the physical findings, that the diagnosis is based.

Among the causes of rapid heart action is exophthalmic goitre, in which the most constant of the three cardinal symptoms—enlarged thyroid, exophthalmos, and tachycardia—is the persistently rapid heart action, which slows with improvement, and increases in rate as the patient's condition grows worse. Here, again, there is no constant physical

finding to account for the tachycardia, and at present we must class this among the symptoms due to a disorder of nutrition, of which the nervous unstability and loss of weight are other evidences.

By palpitation we mean a conscious distress in the region of the heart or epigastrium, accompanied by tumultuous, excessive, rapid, and often vigorous heart action. In some people this can be brought about by relatively slight reflex irritation, a sudden emotion of fear or joy, or indigestion, or it may develop during sleep, and without apparent antecedent irritation of any kind. The subjective symptoms, the manner of development, and the discovery of wholly normal conditions on physical examination, serve to make the diagnosis.

Palpitation as a subjective symptom may occur in failure of, or failing, compensation, in cases of high arterial pressure, and in cases of mitral stenosis, particularly among cardiac valvular disorders. It may accompany attacks of paroxysmal tachycardia, but its association with this condition is not constant, nor is subjective cardiac distress at all a constant accompaniment of even severe grades of advanced valvular disease with failing compensation.

In one point of view the physical diagnosis in functional disorders may be said to rest, not on negative, but on positive evidence. Percussion and auscultation afford the means, not only of excluding inflammatory affections and lesions, but of demonstrating the fact that the organ is sound at

least as regards freedom from ordinary lesions. That its size is normal is shown by the normal situation of the apex beat, of the lateral boundaries of the precordia, and of the area of the superficial cardiac space. That the valves are unaffected is shown by the normal characters of the heart sounds. These positive facts, taken in connection with the absence of morbid signs, render the diagnosis certain. Positive assurance of the soundness of the organ should be withheld until painstaking examination of the heart, not only by auscultation and percussion, but by all the various accessory methods, such as the x-ray and electrocardiograph, have been carried out. Thus will the opinion of the examiner carry the weight which is desirable, in order to secure for the patient relief from anxiety and apprehension.

Functional disorders are not infrequently associated with lesions with which they have no essential pathological connection. A patient with lesions which are either innocuous or attended with little, if any, inconvenience, may suffer from disturbance of the action of the heart produced by causes which are wholly independent of the lesions. There is a liability, in these cases, to the error of attributing the disorders to the lesions, and thus forming an exaggerated estimate of the importance of the latter. To decide how much of the disturbed action of the heart is due to a superadded functional affection is not as easy as to determine that lesions do not exist. The decision must be based on the character, degree,

or extent of the lesions, as evidenced by the physical signs. In this connection may be stated a practical maxim which it is well to bear in mind whether functional disorders exist or not—namely, valvular lesions rarely give rise to much inconvenience until they have led to enlargement of the heart; and enlargement, either with or without valvular lesions, as a rule, does not lead to the serious effects which are characteristic of cardiac disease, so long as the enlargement is due to predominant hypertrophy, and not to dilatation.

CONGENITAL CARDIAC DEFECTS.

There are three kinds of cardiac defects which give signs of enough constancy to be susceptible of diagnosis during life. They are transposed viscera, *i. e.*, a right-sided position of the heart, spleen, and stomach with a left position of the liver; defects of closure between the systemic and pulmonary circuits, *i. e.*, patent interauricular septum (patent foramen ovale); patent interventricular septum; patent ductus arteriosus, or ductus Botalli; defects in the formation of the tricuspid or pulmonary valves resulting in stenosis.

The signs of a right-sided position of the heart on inspection, palpation, percussion, and auscultation differ from the signs obtained in normal individuals simply in the change from the left to the right of the midline. This condition must be sharply dis-

tinguished from a merely displaced heart resulting from acquired inflammatory processes within the chest, or the pressure of tumors, pneumothorax or pleural exudates; and, of course, unaccompanied by the transposition of the abdominal viscera.

Patent foramen ovale may give no signs and interfere in no way with the life of the individual. It may cause death. There may be cyanosis and clubbing of the fingers. There may be a harsh systolic murmur, heard best over the second, third or fourth left interspaces, and not transmitted along the pulmonary artery. The murmur may be diffuse. It may be presystolic in time and it may be both diastolic and systolic.

Perforate interventricular septum may be congenital or acquired. It is one of the commonest congenital lesions and is frequently combined with pulmonary stenosis. The two causes of origin are to be distinguished by the history and records of examinations of the heart at different times. The usual signs are: Cyanosis, clubbing of the fingers, and bulging precordium, all of which may be absent; a thrill over the precordium, extending throughout systole, and a loud, rough systolic murmur heard best at the third or fourth left interspaces, near the sternum, and widely diffused downward to the left, and usually audible in the back.

Patent ductus arteriosus (ductus Botalli) presents fairly constant signs. There is usually a visible systolic pulsation in the second left interspace. There is

a systolic thrill which may even continue through diastole. There are the signs of dilatation and hypertrophy of the right ventricle. There is an increase of dulness to the left of the sternum, running from third to first rib, and across the manubrium of the sternum about 1 or $1\frac{1}{2}$ inches wide, indicating the dilated pulmonary artery. There is usually a loud systolic murmur of maximum intensity at the second or third left interspace, transmitted up to the top of the sternum and left clavicle. There may be an increased pulmonary second sound.

For diagnosis of tricuspid and pulmonary stenosis the reader is referred to descriptions of these lesions on pp. 315 and 336.

THORACIC ANEURISM.

In thoracic aneurism the physical conditions concerned in the production of signs, are: (1) A tumor within the chest, of variable size, formed by the aneurismal sac; (2) pulsation of the tumor from the passage of blood into the sac with each ventricular systole, and the expulsion of blood in the diastole by the recoil of the coats of the aneurism; (3) the size of the opening into the sac as affecting the quantity of blood which it receives with each systole; (4) the quantity of stratified fibrin which the sac contains; (5) the point of connection with the aorta of the aneurismal tumor; and (6) the direction in which the tumor extends, together with its relations to the

lungs, the trachea, the primary bronchi, the intrathoracic veins, the esophagus, the recurrent laryngeal nerve, the sympathetic nerve, either the innominate or subclavian artery, the ribs, sternum, and vertebral column.

With reference to diagnosis, it is well to bear in mind that, in the majority of cases, an aortic aneurism is connected with either the ascending portion, or the junction of the ascending and the transverse portion of the arch, and that the tumor generally extends to the right in a lateral or anterolateral direction. The physical diagnosis is more easily made when the aneurismal tumor is thus directed. The signs are less available if the aneurism arise from the transverse or descending aorta, and especially if the tumor extends in a direction downward or backward.

An aneurismal tumor which has made its way through the walls of the chest, or which, without perforation, causes a circumscribed bulging obvious to the eye and touch, presents the following diagnostic signs: An impulse is seen and felt which is synchronous with the ventricular systole. The force of the impulse is variable, depending, aside from the force with which the left ventricle contracts, upon the size of the orifice between the sac and the artery, and the quantity of fibrin which the sac contains. Following the impulse and coincident with the closure of the aortic valves, a shock (the diastolic shock of the second sound) may often be perceived if firm pressure be made with the hand. This is due to the vibration

caused by closure of the aortic valves being accentuated by the resonator action of the sac wall in aneurisms of the ascending and transverse arch. A vibration or thrill with each impulse is sometimes a marked sign, but is often wanting. Frequently, but by no means constantly, a systolic murmur is heard over the tumor, and there may be also a diastolic murmur produced by the passage of blood from the sac. Dilatation of the first portion of the arch of the aorta usually occurs, of a sufficient degree to establish an aortic regurgitation with its characteristic murmur. The heart sounds are transmitted to the tumor with more or less increased intensity. There is notable dulness on percussion over an area corresponding to the space within the chest which the tumor occupies. If the tumor be of considerable size, it may produce condensation of lung around it; the area of dulness on percussion will be in this way extended beyond the limits of the tumor. Under these circumstances, bronchial respiration and bronchophony may be produced. Pressure upon the superior vena cava causing dilatation of the corresponding veins is frequent. If the aneurismal sac be beneath the integument, there may be to the touch a sense of fluctuation.

With the foregoing signs, the physical diagnosis scarcely admits of doubt. Some of the signs may be produced by a tumor, not aneurismal, so situated as to receive and conduct the aortic impulse. The chances of a tumor being so situated as to stimulate the signs of an aneurism are few. I have met with a case of

empyema in which perforation of the chest took place in the second intercostal space on the right side of the sternum, giving rise in this situation to a fluctuating tumor which had a strong pulsation. On a superficial examination the case seemed clearly one of aneurism; but an examination of the chest showed the right pleural cavity to be filled with liquid, and a puncture in the axillary region gave exit to a large quantity of pus, the pulsating tumor disappearing after a certain quantity of the purulent liquid had escaped. I have met with a similar pulsating tumor, incident to empyema, on the posterior aspect of the chest.

When, from its small size or its situation, an aneurismal tumor does not come into contact with the thoracic wall, and when it is situated beneath the sternum, signs obtained by palpation and inspection being absent, the physical diagnosis is less easy. Important signs are: dulness within a circumscribed space situated in the course of the aorta; an abnormal transmission of the heart sounds within this space, and the presence of murmurs. These signs are not always available, and when present they are not sufficient for a positive diagnosis. Other physical evidence, and the presence of certain symptoms, render the existence of aneurism highly probable, either with or without the foregoing signs. If an aneurismal tumor press upon the trachea, it occasions a tracheal rale, or stridor, together with weakness of the respiratory murmur on both sides of the

chest. Less degrees of tracheal compression are demonstrable by the stridulous cough, which may be readily imitated by firm pressure with the thumb in the suprasternal notch. If the tumor press upon a primary bronchus, it occasions diminished or suppressed respiratory murmur on one side, and increased respiratory murmur on the other side of the chest. These physical signs should always lead to a suspicion of aneurism in a person over forty years of age. Symptoms which should excite this suspicion and lead to careful physical exploration for the physical signs of aneurism are: dyspnea from spasm or paralysis of the muscles of the glottis, and aphonia or impairment of the voice without evidence of laryngitis; these symptoms denoting either excitation or pressure of the recurrent laryngeal nerve; inequality of the pupils due to pressure upon the cervical sympathetic; dysphagia from pressure upon the esophagus; congestion of the face, neck, and upper extremities from obstruction of the vena cava or the vena innominata; inequality of the radial, carotid, and subclavian pulsation on the two sides, or the absence of pulsation on one side, and contraction of one of the pupils. A valuable sign in aneurisms of the transverse to descending aorta, just those cases in which percussion and auscultation may prove negative, is the tracheal tug. This consists in a downward movement of the larynx with systole due to pulsations of an aneurism pushing down the left bronchus. It is detected by lifting the cricoid

cartilage upward between the thumb and forefinger. The erect posture is usually essential and the head should not be thrown backward. These symptoms not only render probable the existence of aneurism, but indicate its situation as regards the aorta and the direction in which the aneurismal tumor extends.

An aneurism may be suspected, wrongly, when, owing to shrinkage of the lung, or deformity of the chest, either the aorta or the pulmonary artery just above the heart is removed laterally from its normal situation, or brought into contact with the walls of the chest in the second intercostal space, so as to give rise to an appreciable impulse. A murmur may also be present at the point of impulse. An error of diagnosis under these circumstances is avoided by finding an adequate explanation of the signs just noted, and by the absence of other signs and of symptoms which are diagnostic of aneurism.

In conclusion, an aortic murmur, however intense or rough, is never evidence of aortic aneurism, and, on the other hand, the absence of murmur is by no means sufficient for the exclusion of aneurism.

CHAPTER X.

EXAMINATION OF THE ABDOMEN.

Inspection—Palpation — Percussion—Auscultation—Stomach —Liver—Spleen—Kidneys—Abdominal wall—Other organs.

In making an examination of the abdomen it is presupposed that the anatomy and physiology of the walls and viscera have been already mastered. The important points of the change of position of the abdominal contents during respiration; the change in size and position of the parts of the gastro-intestinal tract according to the amount and character of their contents; the changes incident to filling and emptying of the bladder; the alterations in the size and position of the uterus must all be kept in mind while examining the abdomen.

Inspection.—On inspection we note the occurrence of normal or abnormal shadows, betraying the movements of viscera from the descent of the diaphragm, or in the course of peristalsis of their muscular walls. Prominences can be detected, especially with the eyes on the level of the abdomen, and the patient's feet toward the source of light, in the recumbent position. Pulsations are noticed. It is normal to see an epigastric systolic impulse. Peristalsis is not visible

under normal conditions of the gastro-intestinal tract except in extreme emaciation. Visible peristalsis almost invariably indicates obstruction, and the site of the obstruction may often be located by close attention to the direction and point of cessation of the peristaltic waves. Peristaltic waves may be seen in the colon when there is extreme or acute obstruction, which go in the normal and in the reverse direction. The lower and upper limits of the stomach, the lower border of the spleen and liver, the level of the uterus or a distended bladder may be observed on inspection. Tumor masses may be noticed as abnormal, fixed or movable prominences as shown by shadows. We observe the presence of obesity, the relaxed, pendulous, or contracted and sunken parietes. We look for edema, the rounded abdomen of meteorism, the bulging flanks of ascites, dilated veins, paying particular attention to the system which is enlarged and the direction of flow. We notice whether there is support by the abdominal walls of their contents, or whether there is a general splanchnoptosis or prolapse of the viscera with downward and forward displacement. Inspection should be made in the dorsal, lateral, and erect positions.

Palpation.—Palpation of the abdomen is to be done with the patient in the lateral or dorsal positions, the abdominal walls being relaxed by drawing up the knees and raising the head on pillows. The examining hands should be warm and dry. To effect perfect relaxation examination may be made in a warm bath,

or in extreme need under anesthesia. It may be necessary to empty the stomach, rectum, and bladder. We note resistance, fluctuation, the presence of a fluid wave, tumor masses, sensitiveness to pressure, the movable borders of viscera, or the outlines of deeply seated and fixed organs. We may note aortic pulsation, the presence of mesenteric and retroperitoneal glands, and the anterior surface of the vertebræ in thin subjects. Errors may arise from reflex muscular tension, fat masses in the omentum, or mesentery, or attached to the gut, and from fecal masses.

Percussion.—Percussion of the abdomen is a less reliable guide than palpation. The note becomes more resonant with increase of gas in the intestine or in the free peritoneal cavity, but with extreme distention of the intestine the note loses its tympanitic quality; if there is gas in the free cavity there may be shifting dulness from coincident fluid exudate. There may be obliterated liver dulness whether the gas be free or in the intestine. The note is dulled by a diminution of gas in the intestines; presence of localized solid or fluid contents in the intestines; presence of localized inflammatory or neoplastic tissue superficially situated; by fluid accumulation in the free cavity, in which case the line of dulness or flatness should shift with the patient's change of position; and by thick abdominal walls.

Percussion of the stomach, colon, and small intestines is unreliable as compared with inspection and palpation; although very light percussion, or auscultatory

percussion will give fairly accurately the limits of stomach and colon if distention with gas or fluid is used to exaggerate the notes.

Percussion of the borders of liver and spleen is merely confirmatory of facts better observed on palpation.

Percussion of the distended bladder gives marked dulness if a light stroke is used.

Percussion over the enlarged uterus gives a similar change of note, but palpation, catheterization, and vaginal examination serve to prevent confusion in this instance.

Percussion of the kidneys is unprofitable.

Auscultation. — Auscultation, except as combined with percussion, gives no positive results of value except in identifying the occurrence and location of the fetal heart sounds, the uterine, placental, and cord murmurs in pregnancy; murmurs due to the pressure of tumors on the abdominal aorta, or over abdominal aneurisms; those from compensatory veins in hepatic cirrhosis; and friction rubs in perihepatitis and perisplenitis.

STOMACH.

Examination of the stomach should include a determination by palpation and inspection of its size, location, character of its contractions, and its outlines when empty and when distended. Visible peristaltic waves seen passing from the left hypochondrium across the abdomen to end at the right of the umbilicus in a temporary prominence are diagnostic of pyloric stenosis.

Points or areas of acute tenderness may be made out over its surface. Tumors of its walls or of the pylorus may be detected. By dipping or quickly striking the wall over the stomach we may elicit splashing when the stomach contains food, thus indicating its ability to empty itself, or its motility and the patency of the pylorus. In spite of the apparent accuracy of some of these methods combined with the use of the stomach tube, there is no question that reliable *x*-ray examinations will give us more exact data as to size, location and function than all the other methods combined, and this is equally true with regard to the other parts of the intestinal tract.

LIVER.

The liver may be palpable in health owing to unusual shape of the costal margin or angle, or when displacement downward has resulted from faulty position or dress. The border may be palpable under these conditions even though its consistency is not unduly resistant. The liver may be displaced downward, or upward, in hydro- or pneumothorax, or in hydropericardium, and in meteorism, ascites, and pregnancy. The gall-bladder may be palpable and detected on percussion, to the right of midclavicular line at the costal margin, if it is distended by any of the obstructive affections which may interfere with the patency of the cystic duct. Enlargement occurs in the direction of the umbilicus. Detection of tenderness in the region of

the gall-bladder, or just below it, may be an important point in distinguishing affections of the gall-bladder from more or less general abdominal pain, or appendiceal or gastric pains. Auscultation may determine the presence of friction on respiration.

We find a slight enlargement of the liver in acute catarrhal jaundice.

In liver abscess the liver may be painful, irregularly increased in size and give friction on auscultation.

In interstitial hepatitis (cirrhosis) there is usually uniform enlargement. The surface is firm and resistant, the edge hard, and unevenness may be detected. The spleen is usually enlarged as well. There is apt to be slight icterus, enlargement of superficial abdominal veins, and ascites.

In carcinoma of the liver there is unequal enlargement and a lumpy surface; there is usually icterus and ascites, but the spleen is not enlarged.

In echinococcus cyst of the liver there may be a fluctuating tumor. Icterus is often present. The spleen is not enlarged, and ascites is not present.

In chronic passive congestion of the liver we find an enlarged, firm, sometimes tender and often pulsating liver. Icterus may occur but does not persist. The spleen is not enlarged, and ascites is not present, unless there is edema of dependent parts of the body or hydrothorax as well.

The liver may be enlarged in syphilis, when we find it hard and lumpy. The spleen frequently large; ascites and icterus present or absent.

The amyloid liver is evenly enlarged, and smooth and firm. The spleen is enlarged. No icterus or ascites.

In leukemia the liver is enlarged but to a less degree than the spleen. No icterus or ascites.

The liver is decreased in size in atrophic forms of chronic hepatitis, and in acute yellow atrophy of the liver. In the former we find an enlarged spleen, much ascites, slight icterus. In the latter we have extreme icterus, without enlargement of the spleen, or ascites.

SPLEEN.

The outlines of the spleen can be determined by percussion, except for its posterior pole (*vide* p. 81).

By palpation the lower pole of the spleen is to be felt if the spleen is enlarged. Palpation should always be carried out in two ways, unless the spleen is easily felt. With the patient in the dorsal position the examiner faces the patient, standing on his right side, and palpates gently with the flat of the fingers in the left hypochondrium, at or just beneath the costal margin at the anterior axillary line and also at about the midclavicular line. It is advantageous to simultaneously lift upward with the right hand in the upper left lumbar region. The patient is directed to breathe in deeply, and as the diaphragm descends the soft tip of the spleen will be felt, with moderate enlargement. Relaxation of the anterior pressure just at the height of inspiration often allows the spleen to flip under the finger-tips, producing a very characteristic

sensation. If this procedure fails, the examiner should stand at the patient's back while the patient lies upon his right side. The examiner may palpate as before or else, facing toward the patient's feet, hooks the fingers of his right hand over the costal margin, to feel the spleen as it is forced down in inspiration. When the spleen is markedly enlarged it may be missed if the examiner's hand is applied too near the ribs or too far posteriorly in the flank. Tenderness and unevenness of the margin may be observed.

If the splenic flexure of the colon is full of feces, the splenic dulness cannot be made out. If the stomach contains food, percussion over the spleen must be made with the patient on his right side.

Emphysema, meteorism, or ascites may cause a loss of splenic dulness. If the spleen is palpable, or the dulness reaches the anterior axillary line the spleen is enlarged. Enlargement occurs in many infectious diseases, especially in typhoid fever, and in malaria, typhus fever, acute endocarditis, and sepsis. The spleen is enlarged in cirrhosis of the liver, infarct of the spleen, amyloid disease, and the true and pseudoleukemias. The spleen may be enormously enlarged without apparent cause in tropical diseases, splenic anemia, polycythemia, splenomegaly, and Banti's disease.

KIDNEYS.

The kidneys cannot be percussed with profit. Changes of size and position can usually be determined

by palpation. Palpation is used with the patient lying on his back, side, or abdomen, or in a semi-erect seated posture. An effective way of detecting a movable kidney is to grasp the abdominal wall gently with one hand, the palmar surface of the fingers against the lumbar muscles and the thumb pressing backward. The lower pole of the kidney if it descends on inspiration forces the thumb and fingers apart. By using bimanual palpation with one hand behind, just below the eleventh rib, and the other pressing back against the abdominal wall, the posterior hand appreciates increased resistance, as an enlarged kidney is forced down in inspiration. An enlarged spleen is not palpable posteriorly. When freely dislocated even the upper pole may be palpated. Enlarged kidneys are not so easily felt, nor do they so often move with the diaphragm, as do prolapsed kidneys. The colon is usually pressed forward by an enlarged kidney in contrast to being pressed backward by an enlarged spleen, the relative positions of colon and kidney being readily ascertained after artificial distention of the colon with gas.

ABDOMINAL WALL.

Abdominal distention occurs in meteorism, which is a common incident in enterocolitis, typhoid fever, in peritonitis, and in obstruction of the gut. In peritonitis there is extreme tenderness either generalized, or, if the process is localized, as an appendiceal abscess, inflamed gall-bladder or ruptured gastric or intestinal

ulceration, the tenderness may be sharply circumscribed, with muscular spasm extending more or less widely. At a point half-way between the anterior superior spine of the ilium and the umbilicus, the tenderness of appendiceal inflammation is usually sharply localized (McBurney's point), and, if the colon is distended with air, this point may be the seat of acute pain in chronic inflammations of the same region.

In perforation of the wall of the stomach or intestine there is apt to be a marked increase in the intensity of abdominal tympany, and liver and splenic dulness may disappear. Liver dulness may also be absent in extreme tympanites alone. With this there is rapid, weak pulse, and signs of a general peritonitis.

In obstruction of the gut the signs may develop acutely or slowly, according to the nature of the cause, whether kinking, intussusception or embolus on the one hand, or progressive tumor growth, etc., on the other hand. The small, weak, rapid pulse, and absence of passage of flatus and feces, together with violent peristalsis, distention, and vomiting make the picture striking. The rectum and usual sites of herniæ should be examined.

The abdomen may be distended from ascites in cardiac, renal, or hepatic disease, or in such peritoneal inflammations as occur in peritoneal carcinosis and tuberculosis. In the latter two conditions there is often little or no tenderness of the abdomen, and in each condition the exudate may be localized or encapsulated in some one portion of the peritoneal sac.

OTHER ORGANS.

The rectum should always be examined digitally, and if necessary instrumentally. The bladder and vagina should be explored if there is any indication of interference with their function or structure, and often for the sake of determining the position of adjacent inflammatory or neoplastic processes. The stomach should usually be explored, information at the same time being obtained as to the patency and size of the esophagus.

CHAPTER XI.

ORDER OF PHYSICAL EXAMINATION.

Order of physical examination—Standard classifications of pulmonary tuberculosis.

For the sake of having a reasonably complete record of a physical examination it is imperative that the student should become so used to a logical and definite order that omissions are unlikely to occur. To this end the following scheme or order of physical examination is included:

General Appearance.—Height, weight, nutrition, type of physique, active and passive posture. Expression.

Constitutional Signs.—Body temperature. Pulse rate. Respiration rate.

Psychical Conditions.—Intelligence, consciousness, restlessness, convulsions, delirium, apathy, stupor, coma, speech, memory.

Skin.—Texture, color (cyanosis, icterus, pigment), moisture, temperature, edema, emphysema, hemorrhages, insect bites, eruptions, scars, collateral, venous, or capillary circulation, striæ, desquamation.

Head.—Shape and size, symmetry.

Eyes.—Position, motion, equality and size of pupils, reactions of pupils to light and accommodation, acuteness of vision, conjunctivæ.

EARS.—Hearing, mastoid tenderness, tophi, discharge.

NOSE.—Patency of nares or obstructions, odor, secretions, perforation of septum.

LIPS.—Color, moisture, eruptions.

TEETH.—Gums swollen, puffy, pyorrhea, lead line, caries, absence, saliva.

PALATE.—Broad, narrow, arched, perforated.

PHARYNX.—Color, exudates, tonsils.

NECK.—Glands, lymph nodes, thyroid, enlargement or pulsations of veins and arteries, thrills, murmurs, venous hum.

LARYNX.—Tracheal tug, cough, voice.

ESOPHAGUS.—Swallowing.

VERTEBRÆ.—Curvature, tenderness, mobility.

CHEST.—Variations in breadth or depth, asymmetry of form or function. Abnormal impulses. Shape, funnel, rachitic, with rosary, and costal groove. Scapulæ position. Expansion, measurement. Unilateral or bilateral bulging or retraction of interspaces.

RESPIRATION.—Rate, type, diaphragm phenomenon, retraction of interspaces, Biot's or remittent breathing. Cheyne-Stokes or periodic breathing, dyspnea, inspiratory or expiratory, cough, expectoration.

Palpation.—Fremitus, vocal, bronchial, pleuritic.

Percussion.—Systematic, of whole chest. Particular attention to comparison of apices and determination of lung borders in inspiration and expiration.

Auscultation.—Breath and voice sounds, adventitious sounds.

Heart.—Inspection, apex, location and character of beat; presence of abnormal pulsation.

Palpation.—Site and character of apex beat; site and time of thrill; abnormal pulsation; shock of second sound..

Percussion.—Borders of heart, change on altered position.

Auscultation.—Character of first and second sounds, or their component parts at the several valvular areas, murmurs, place, time, maximum intensity, direction of transmission, character, effect of change of position.

Pulse.—Size, force, frequency, rhythm, tension or blood-pressure (instrumental determination), vessel wall, character, symmetry on two sides, delay.

Abdomen.—Form, circumference, umbilicus, resistance, percussion, palpation, visible movements, tumors, size, consistency, mobility, relation to respiration and to other organs, fluctuation, tenderness, auscultation of abnormal sounds.

Liver.—Upper limit, lower border, character of surface and edge, smooth, nodular, tender, pulsating.

Spleen.—Area of dulness, edge, character of surface.

Stomach.—Size, visible movements, splashing, tenderness, tumors, if necessary distention with gas or fluid and use of tube to empty.

Kidneys.—Palpation; bladder, retention, palpation, and percussion.

Extremities.—Joints, movements, size, tenderness, musculature, atrophy, hypertrophy, altered tonicity, trophic abnormalities.

Lymph Nodes.—Inguinal, axillary, and epitrochlear.

Skin.—Color, eruptions.

Reflexes.—Tendon, joint, skin reflexes, also general sensibility, locomotion, and muscular efficiency.

Special examinations to be made whenever necessary to a complete diagnosis. Ophthalmoscopic, laryngoscopic, and rhinoscopic, otoscopic, rectal, vaginal, urethral, and cystoscopic, special neurological tests, sounding of esophagus and stomach.

STANDARD CLASSIFICATIONS OF PULMONARY TUBERCULOSIS.

For the sake of accuracy in using terms descriptive of the various stages or degrees of severity of pulmonary tuberculous lesions the student is advised to avail himself of the definitions which follow.

A. Turban's Classification.

According to Turban we may define the lesion as of three grades:

By grade I we mean a slight lesion extending at most to the volume of one lobe or two half-lobes.

By grade II, slight lesion extending farther than I, but at most to the volume of two lobes; or a severe lesion extending at most to the volume of one lobe.

By grade III, all lesions which in extent of the parts affected exceed II.

By "slight lesion" we understand disseminated

centres of disease which manifest themselves physically by slight dulness, by harsh, feeble, or bronchovesicular breathing, and by rales.

By "severe lesion" we mean cases of consolidation and excavation such as betray themselves by marked dulness, by tympanitic resonance, by very feeble bronchovesicular, bronchial or amphoric breathing, by rales of various kinds.

Purely pleuritic dulness, unless marked, is to be left out of account; if it is serious, the pleurisy must be mentioned under the head of tuberculous complications.

B. The National Association Classification.

The National Association for the Study and Prevention of Tuberculosis has adopted the following classification:

Incipient (Favorable).—Slight initial lesion in the form of infiltration limited to the apex or a small part of one lobe. No tuberculous complications. Slight or no constitutional symptoms (particularly including gastric or intestinal disturbances or rapid loss of weight). Slight or no elevation of temperature, or acceleration of pulse at any time during the twenty-four hours, especially after rest. Expectoration usually small in amount or absent. Tubercle bacilli may be present or absent.

Moderately Advanced.—No marked impairment of function either local or constitutional. Localized consolidation, moderate in extent, with little or no evi-

dence of destruction of tissue, or disseminated fibroid deposits. No serious complications.

Far Advanced.—Marked impairment of function, local and constitutional. Localized consolidation intense; or disseminated areas of softening; or serious complications.

Miliary Tuberculosis (*vide* p. 238).

INDEX.

A

I

J

K

L

M

N

O

P

S

T